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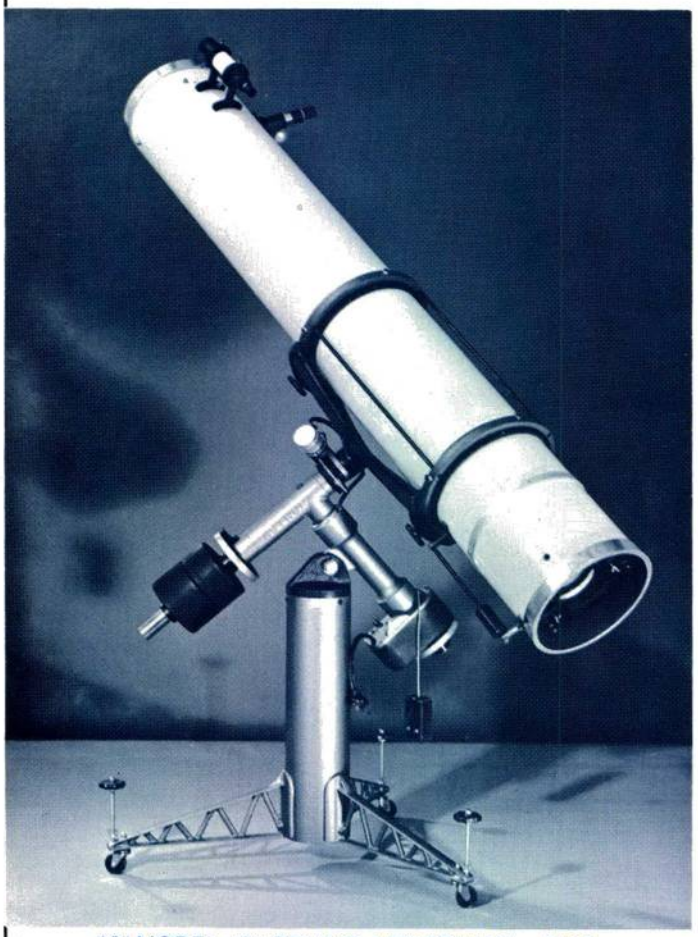

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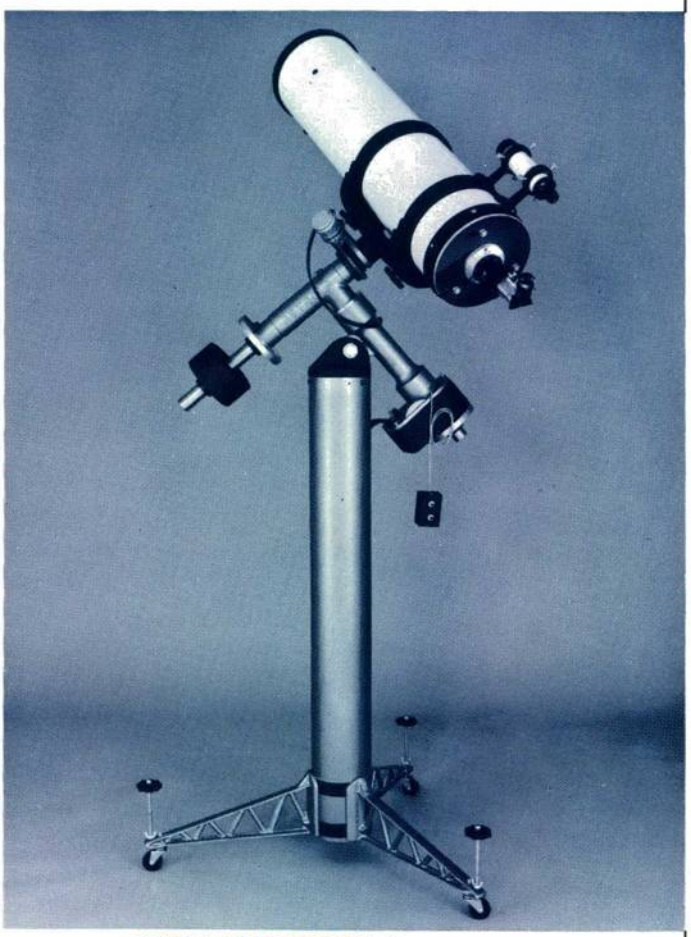

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COVER

U.S. Naval Observatory Photograph

The Bubble nebula, a uniquely molded cloud of interstellar gas in the constellation Cepheus, may be a stellar birthplace. Such cosmic incubators consist of huge clouds of gas — mostly hydrogen — with small amounts of other elements. The nebula's illumination comes from nearby stars. The birth and death of stars are key elements that govern the probability of intelligent life arising in various places throughout the Milky Way galaxy, as told by Ben Bova on the following pages. (This nebula, known officially as NGC-7635, is a very difficult object for the small telescope. It is located about 1/2 degree southwest of M-52 in Cassiopeia.)

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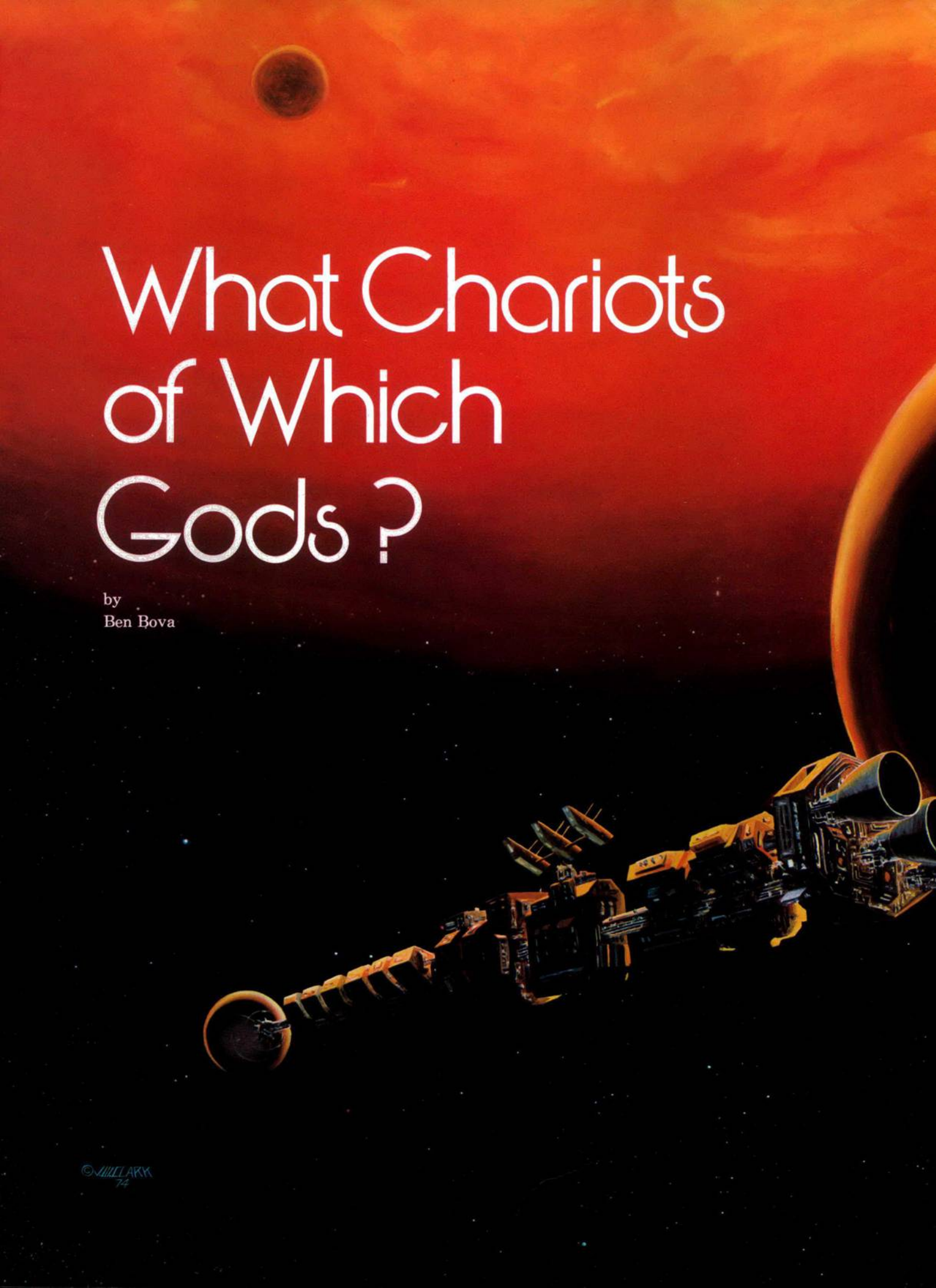
What Chariots of Which Gods?

by
Ben Bova



An astonishing amount of the public's attention has been focused lately on the idea that our planet was visited in prehistoric times by astronauts from other worlds. Presumably, the visitors were wise, benign, and maniacs about large construction projects such as the pyramids and the Easter Island statues.

Maybe there are older, wiser races "out there" among the stars. Maybe they have visited here. Perhaps they are watching us now with gentle amusement as we sweat over our Skylab and Mariner and Pioneer space probes.

But what *evidence* do we actually have? With our optical and radio telescopes, our Orbiting Astronomical Observatories, our penetrating studies of cosmology; what evidence can we put together that shows: (1) that there are indeed other intelligent races in space, and (2) that they have visited Earth?

We could argue for a lifetime over the kinds of evidence offered by the **Chariots of the Gods?** (by Erich von Daniken) believers: quaint paintings found in ancient caves, or markings carved into hillsides and remote plateaus. We could spend equally fruitless time debating whether it was humans or alien astronauts who actually built the pyramids, Stonehenge, etc. That evidence is highly equivocal.

Instead let us turn to the unequivocal laws of physics and chemistry, and the solid observations of astronomy, to see if we can find definite answers.

Are there other intelligent races in space, and have they visited Earth?

It seems almost certain that there is no other intelligent species among the planets of our solar system. Mars and Venus have been exposed by spacecraft probes and radar studies. Mercury, Pluto and our own moon were never expected to be habitats for intelligent races. The Jovian planets are too alien for our purposes — more on that later.

If we seek another intelligent race, it must be out among the stars. Assuming for the moment that brainy aliens are out there, what are the chances that we could find them *now*, today, and have meaningful, fruitful contact with them? Not just radio chats, but long term meaningful interaction in the way the United States interacts with the other nations of Earth — trade, cultural interpenetration, tourism, politics, and even war.

That all depends, of course, on attaining some means of traveling interstellar distances. More than that, it must be fast, cheap interstellar transportation. Otherwise there can be no large scale interactions, no politics, and no trade between us and them.

Look at a parallel from Earth's history.

Since at least Roman times, western Europeans knew that China and the Orient existed. In the Middle Ages, Marco Polo got there and back, spreading wondrous tales that grew each year. But Europe did not interact with China in any significant way. True, Europe engaged in trade with the Arab Middle East and obtained goods from the Orient through Arab middlemen. The Mideast was close enough for Europeans to reach on foot, if they had no other way to get there. Europe traded with the Middle East, exchanged scholarly works (which is why most of the stars in the sky have Arabic names), and engaged in the pious slaughters called the Crusades.

But there was no direct trade and no conflict with China. Once deep-ocean sailing vessels were perfected, however, Europe did indeed contact China directly and treated the Orient to Western technology, trade, disease and war. Today, of course, with intercontinental rockets and instant communications, everybody on the globe can interact politically with everybody else.

The same rule will apply to interstellar politics. There may be glorious civilizations in the Orion complex, or even as close as Alpha Centauri. But we know less about them than Hannibal knew about China.

Yet even today it is possible for our scientists and engineers to visualize starships based on technology that might be available in less than a century. If and when we can make trips to the nearest stars within a human lifetime, we'll have reached the Marco Polo stage of interstellar contact — adventure, strange tales, and stranger artifacts. But no lasting political relations, for better or worse. This is the stage that **Chariots of the Gods?** advocates are talking about: rare visits, spaced thousands of years apart, by Marco Polo type explorers from other civilizations.

There can be little tourism — except of a scientific variety — when a person can visit another star system only once in a lifetime, and the trip would consume a fair portion of his lifespan.

The exploration of the red supergiant star Antares is conducted by a 22nd century starship from Earth. The foreground planet and its moon (upper left) were scorched when Antares ballooned to its present 450 million mile diameter. Antares is 400 light-years from Earth, but from here — less than 100 million miles away — it fills much of the sky. Turbulence in the star's surface layers is easily seen from this vantage point. Bova believes technically advanced life is relatively rare in our galaxy and consequently we may very well be the first beings to explore this and other star and planet systems in our neighborhood.

Artwork by John W. Clark

It is also difficult to picture commerce and trade relations based on one ship per human generation. That's more like a cultural exchange. And even the sternest, most fearless and ruthless general might feel a bit foolish about mounting an attack when he knew he could never see the outcome in his own lifetime.

But the real importance of Marco Polo's adventure was the spur it gave to Prince Henry the Navigator and others, including Columbus. We might wonder, then, why the alleged visits of alien astronauts in ancient times have not been followed up more recently. Have the chariots of the gods metamorphosed into flying saucers?

Now, if you corner a theoretical physicist and feed him enough drinks, chances are that you can get him mumbling about tachyons and things that go faster than light. Einstein's light barrier is starting to look — well — not leaky, perhaps, but at least a little translucent. Perhaps one day spaceships will be able to travel among the stars at speeds far greater than light. Perhaps they do now — alien spacecraft, that is — although we have not seen any evidence of this in our astronomical studies of the heavens.

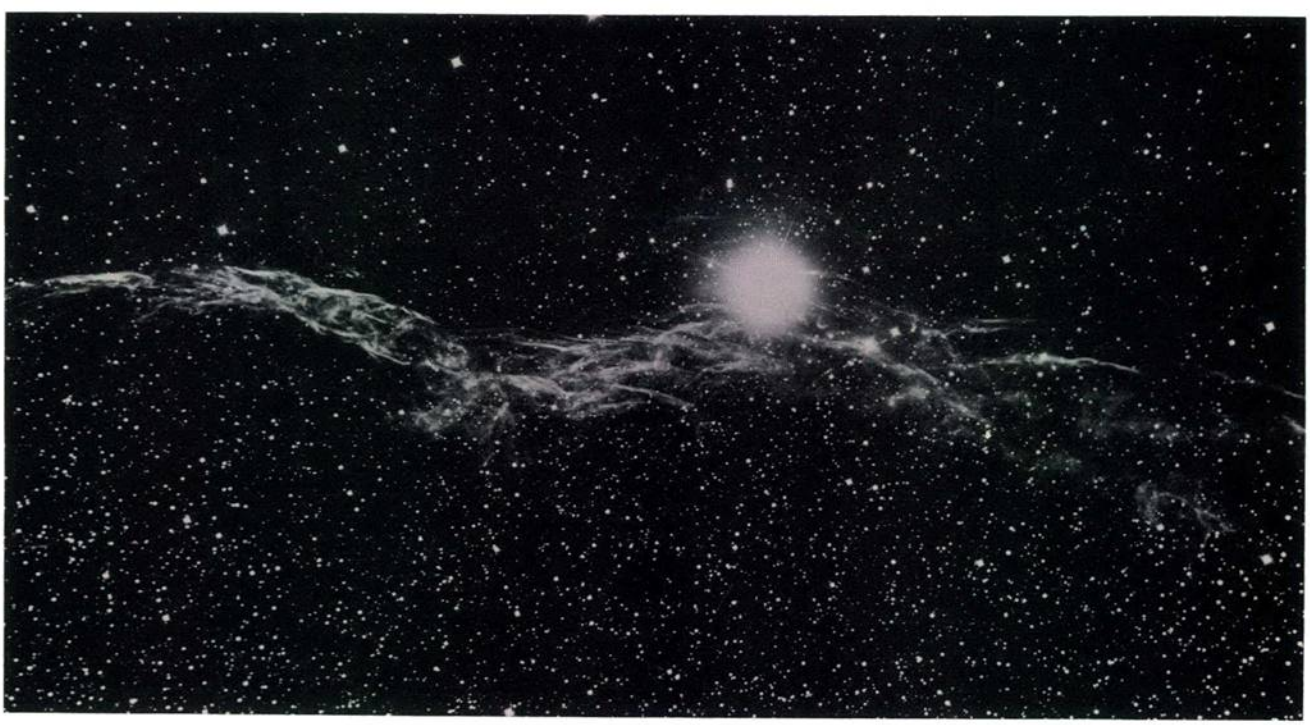
If we had ships that could go faster than light, so that we could easily explore interstellar space, we might get as close and friendly with our stellar neighbors as we are today with the Chinese. But we must realize that there will be many races out among the stars that we simply *cannot* interact with in any useful way, even though we may be able to reach them physically.

For example, we may find races much younger than ours with a correspondingly simple technology and social development. To them, we would appear to be gods, and there would be little we could do for them — or that they could do for us. Would we parade around their world building pyramids and doling out tidbits of our technology?

Certainly we would want to study them to learn more about how intelligence and societies evolve. That would best be done from orbit, where we could remain "invisible" and not disturb them in any way. What could they offer us, except their own artifacts or their own bodies? The artifacts might be interesting as examples of alien art. No matter how lopsided or gruesome they appear, there will be as least one art critic who will discover hidden esthetic values that everyone else has missed and sell the stuff at a huge markup.

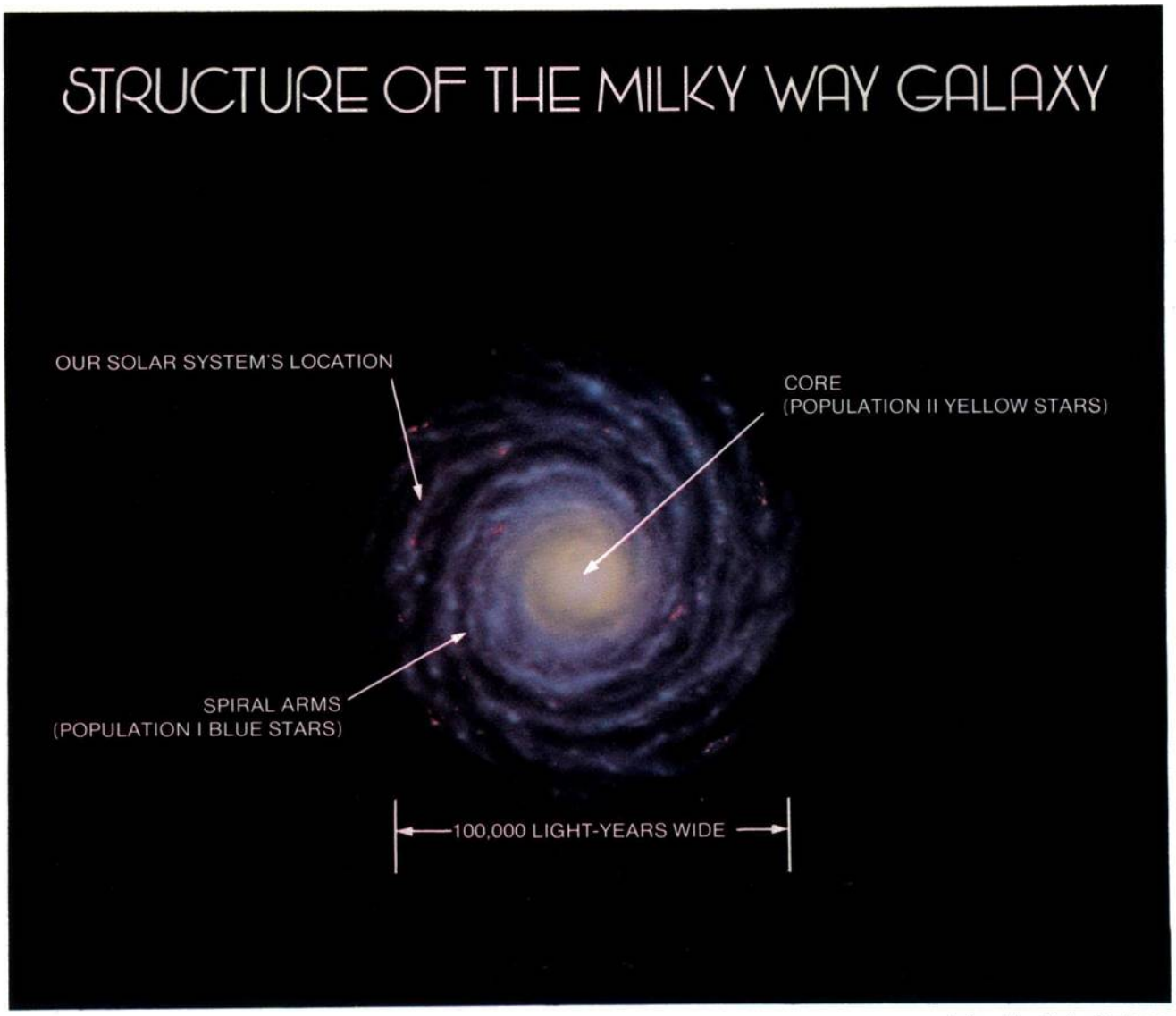
And their bodies?

We wouldn't use them for meat, for biochemical reasons if no other. If their bodies contained some precious chemical substances that could not



Hale Observatories Photograph

The Veil nebula in the constellation Cygnus is part of an expanding wreath of gas emitted by a mighty supernova explosion that occurred 40,000 years ago. As the gas passes through space it sweeps up interstellar material. The effect can clearly be seen since more distant stars are visible in the clear space behind the gas (lower portion) than ahead of it (upper). Stellar remnants such as this are destined to contribute to some future generation of stars.



Artwork by Victor Costanzo

Our star city — the Milky Way galaxy — is a typical large spiral galaxy. It contains about 150 billion stars, more than half of which are clumped near the nucleus. These core stars give the galactic center a yellow hue contrasting with the spiral arms sprinkled with hot blue stars. Those bright blue stars overwhelm yellow stars like the sun to give our galaxy's swirling arms their blue appearance from a distance. We see this effect clearly in the loosely twined arms of M-51, the Whirlpool galaxy, on the facing page. (In the illustration above, the small red blobs in the spiral arms are giant gas clouds like the Lagoon nebula pictured on page 10.) Are we the only technically advanced life in the galaxy?

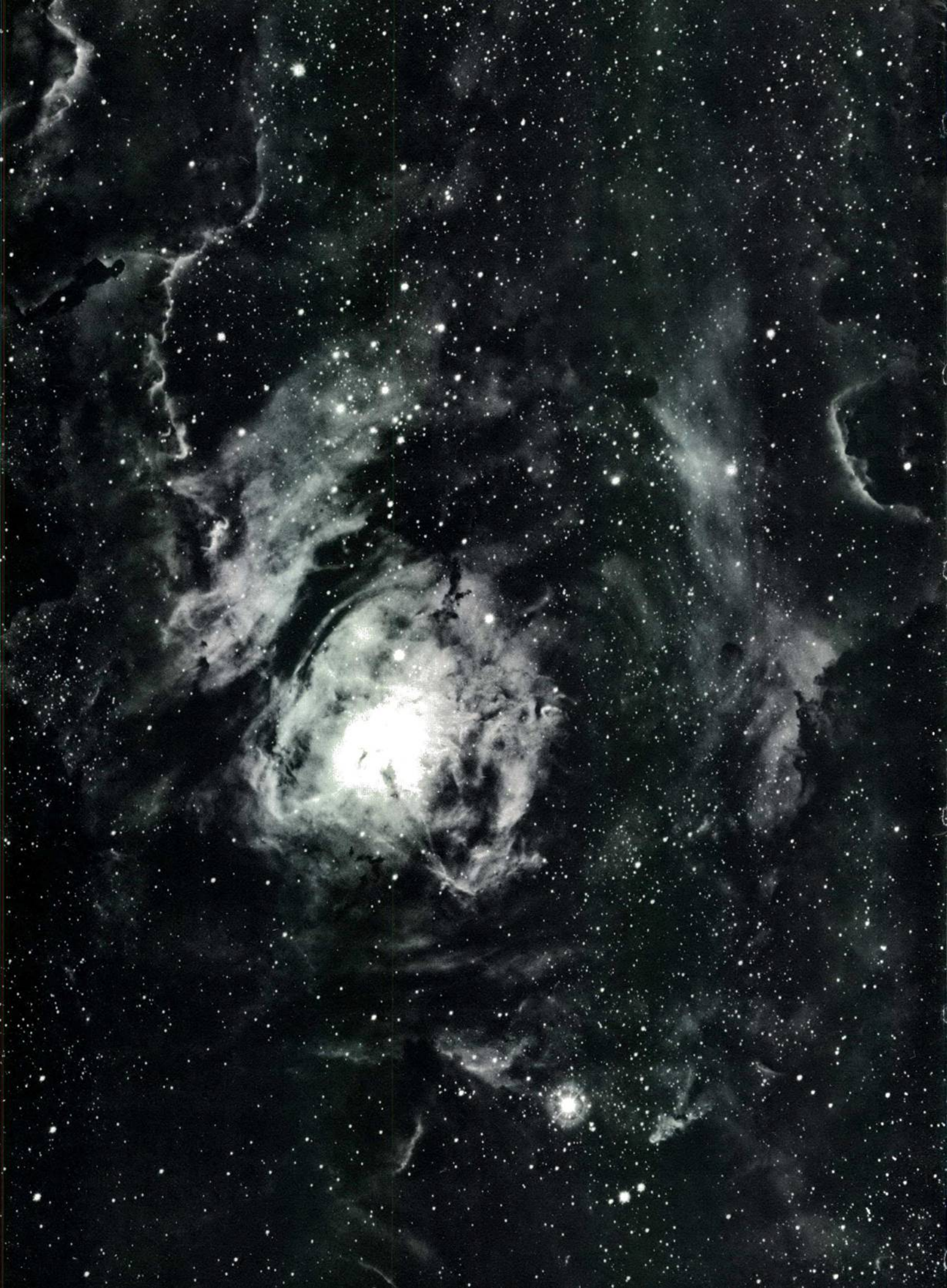
be found elsewhere — the key to immortality or something equally exotic — we would be in a lovely ethical bind. But the chances of that sort of thing are vanishingly small. We certainly would not need muscular slaves in our technological society; electricity is cheaper.

What could we offer such younger neighbors? Only the things that would destroy their culture just as surely as western Europe destroyed the American Indians. Hopefully, by the time we do study such a race, we will have learned not to interfere with them.

If we should try to meddle with a race that is only slightly younger or technologically weaker than we are, their reaction could very well be the same as the Indians' — they would resist us as strongly as they could, probably with guerrilla warfare. As Custer learned a century ago and we learned in Vietnam, "unsophisticated" and "simple" people can turn our own technology against us very effectively. But the Indians were

Sixty billion stars comprise the Whirlpool galaxy, a smaller version of the Milky Way galaxy. Known also as M-51, this 40,000 light-year wide spiral is 14 million light-years distant. The companion galaxy that seems to be an extension of a spiral arm is known as NGC-5195. Many spirals have smaller satellite galaxies such as this. Both our galaxy and M-51 would look similar to the galaxy on page 14 if seen edge-on.

U.S. Naval Observatory Photograph



either killed or absorbed into our culture, and the Vietnamese are going through the same process. That part of the world will never again be a simple, unspoiled, isolated Asian backwater. The same thing would probably happen to a younger race that fights against us; the very act of resistance would destroy their native culture.

What would happen if we contacted a race much more advanced than we are? The same situation, only in reverse. We would have precious little to offer them, except possible curiosity value. And they would be wise enough not to tamper with us — we hope. Playing cowboys and Indians is no fun when you're on the foredoomed side.

A really far advanced race would most likely go its own way, aloof and serene, even if we tried our hardest to make friends. The picture that comes to mind is a puppy chasing a monorail train.

That leaves us with races that are more or less at our own stage of development — intellectually, morally and technologically. That's the kind of race we will have some interactions with. And conversely, if we have been visited in the past by extraterrestrial astronauts, only those whose development is relatively close to our own — give or take a millennium or two — would take any interest in us.

Whether we visit them or they visit us, we will interact strongly only with races that have something to gain from us, and vice versa. Gorillas and angels have so little in common with us that we won't bother them if we find any "out there", nor would they bother us. But other people at our own stage of development, more or less, will provide the interstellar action — even if they are purple and have 16 legs.

Furthermore, any race that interacts with us would probably come from a planet enough like our own home to make this Earth attractive to them. And their home world would similarly be attractive, or at least bearable, to us. This is why, even if an intelligent race exists under Jupiter's clouds — or Saturn's, Uranus' or Neptune's — we probably will interact with them about as much as we do with the denizens of the Marianas Trench. There is simply no common meeting ground. We do not have political relations with dolphins, even if they are as intelligent as we are. We have nothing to trade or fight over.

It boils down to this: Although there may be millions of strange and marvelous races among the stars, if they are physically or intellectually far removed from us we will have little but the most cursory contacts with them — except for possible scientific expeditions. This, of course, does not deny the **Chariots of the Gods?** thesis — a strange race visited our planet thousands of years ago and departed after a rather brief stay. But let's go from the general to the specific, to see if this thesis really stands up in the light of modern knowledge.

There are 37 stars within 16 light-years of our sun; these are our nearby neighbors and we know quite a bit about them. Of these 37 stars, 27 are single, eight are binary stars, and two are triples. Four of these stars are believed to have "dark companions", bodies of planetary mass that are too small and too faint to be seen. In fact, two of the nearest five stars seem to have planets. Since planets are extremely difficult to detect over interstellar distances, we might suspect that there are plenty of them orbiting the farther distant stars. But we just cannot perceive them from here.

The Milky Way galaxy as a whole contains about 100 billion stars. Our galaxy is roughly 100,000 light-years in diameter, and our solar system is some 30,000 light-years from the center.

We have no way of knowing how rare intelligence is, nor indeed whether life itself is a common phenomenon throughout the Milky Way. Radio astronomers have found that the basic chemical ingredients of life such as water, ammonia, and hydrocarbon molecules, exist in interstellar space. In fact, they are found in exactly those locations among the stars where swirling clouds of interstellar gas and dust are building new solar systems. Biological building blocks such as amino acids have been found in meteorites reaching our planet, and organic chemicals exist in the soil samples and rocks brought back from the moon.

Based on balance, it would seem that life is not restricted to our own planet, nor even to our own solar system. Every cosmological test that has been applied to Earth and the solar system has shown that we are not unique. Quite the opposite. Our sun is a rather average star. It appears that planets form around stars naturally. Planets at our temperature range from their star should turn out to look roughly like Earth, with plenty of liquid water. Life on such planets should be based on carbon, oxygen and water, making use of the most abundant materials and the most energetic chemical reactions available. Given enough

The Lagoon nebula is one of the largest star incubators in our part of the Milky Way galaxy – a mammoth cloud of gas and debris over 50 light-years across that will eventually give birth to thousands of stars. Denser condensations, sprinkled through the nebula, can be seen as dark knots and these are believed to be a stage just prior to actual star formation. The Lagoon nebula, also called M-8, can be seen with the unaided eye under good sky conditions six degrees due north of Gamma Sagittarii. The Lagoon is the red blob near the bottom of the color picture on page 37. Despite its brightness the nebula is actually 4,500 light-years distant.

Kitt Peak National Observatory Photograph

STARS – FROM

A Star 10 Times Solar Mass

A trillion mile wide globule of dust and gas — part of a larger nebula — quickly contracts...

...to a 500 million mile diameter protostar, warming up due to the heat of contraction. Within a few thousand years it...

...stabilizes as the core heats up to begin hydrogen "burning". The star is now a main sequence blue giant and remains at this stage for about 200 million years. It is about 10 times the diameter of the sun and 10,000 times as luminous because of its high temperature and rapid rate of burning.

Its hydrogen nearly exhausted, helium and heavier elements are used for fuel; but higher temperatures force the outer layers to balloon into a red supergiant 500 times the sun's present diameter. The colossal star now suffers a series of instabilities that climax in...

...a monstrous supernova explosion. The star's outer layers are consumed in a matter of seconds as elements as heavy as uranium are created. The fireball blasts the bulk of the star into space in an ever widening shock front that adds to the interstellar medium to become the stuff future generations of stars are made from.

The core — usually a few times the mass of the sun — implodes to become either a neutron star (pulsar) or a black hole.

The Sun

A contracting blob of dust and gas — probably part of a large nebula — collapses from a diameter of one trillion...

...to one billion miles in less than 10,000 years. Huge amounts of heat and light energy emitted are contained by a cocoon of dust and gas that eventually becomes planets.

Ten million years after it began to form, the sun has reached its approximate present size and thermonuclear reactions begin as the core temperature reaches 30 billion degrees.

The sun now stabilizes as a main sequence star. It increases in brightness very slowly during the next 10 billion years. Today we are halfway through this uneventful period.

Its hydrogen reserves at the core exhausted, outer layers are consumed. The luminosity increases to about four times today's level.

Red giant structure begins to emerge during the next 600 million years. Luminosity is 1,000 times today's level. Helium burning begins as diameter decreases from 50 times to only 10 times today's values.

Within 30 million years the hot helium reactions bloat the sun to 200 times its present diameter.

Luminosity is 5000 times what it was during main sequence.

Matter is puffed off in shells for 50,000 years forming a planetary nebula.

A white dwarf star no larger than Earth is the final tombstone of a once brilliant star. The dwarf will take billions of years to cool.

BIRTH TO DEATH

A Star 1/3 Solar Mass

The origins of all stars, small and large, seem to be the same: A giant cloud of dust and gas condenses. With small stars all stages of evolution are ponderous compared to the sun and larger stars.

Once its nuclear fires are ignited the star evolves to a stable small red star called a red dwarf. It is less than 1/2 the diameter of the sun and only a few percent of our star's brightness.

For at least 50 and perhaps 100 billion years the red dwarf changes very little, perhaps becoming slightly brighter.

Finally, after a long period of stability it swells to a small red giant as its outer layers of hydrogen are consumed, releasing greater amounts of heat and light. This stage lasts less than a billion years.

Unable to generate enough heat to consume its helium core, the star is doomed and shrinks to oblivion as a dull white dwarf.

Artwork by Victor Costanzo

time, the natural forces that led to the evolution of life on Earth should lead to similar results on similar planets.

But what about *intelligent* life? The underlying question is: What are the ages of the stars around us? If they are about the same age as the sun, shouldn't we expect that they would have had time to develop not only life, but intelligent life — just as we have?

Is it really that simple?

The sun's age has been pegged at roughly five billion years. This is based chiefly on estimates of the amount of the sun's original hydrogen that has been converted to helium through the thermonuclear fusion process that makes the sun shine. Although no one knows how much helium, if any, the sun contained when it first began to shine, five billion years is probably a reasonable estimate of the sun's age since it tallies well with the ages of the oldest rocks found on Earth, the moon, and in meteorites.

Many of the stars around the sun are clearly much younger. The table shows classes of typical stars according to their spectral types, together with estimates of their stable lifespans. By stable lifespan, we mean the length of time that the star remains on the main sequence.

To explain: Stars go through an evolutionary path, a lifespan, much as do living creatures. In the vast spiral arms of the Milky Way, stars are constantly being born and dying. The evolutionary path for an ordinary star, such as our sun, goes like this:

1. A protostar condenses out of interstellar gas and dust. The protostar, a dark clump of mostly hydrogen, is about a light-year wide. It contracts rapidly, falling inward on itself under the gravitational force of its own mass. As it contracts, it naturally gets denser and hotter; its interior temperature rises sharply.

2. When the density and temperature at the core of the protostar reach a critical value, hydrogen fusion reactions are triggered. The gravitational collapse stops, because now heat and light

Hale Observatories Photograph

If the Milky Way galaxy could be viewed edge-on, it would probably appear identical to this galaxy known as NGC-4565. The hub of this colossal wheel is a swarm of billions of Population II stars. Farther out the dust laden arms, the wheel's spokes, swing out 50,000 light-years from the core.

SPECTRAL CLASSES AND LIFESPANS OF STARS

Spectral Class	Surface Temperature (Degrees Fahrenheit)	Color	Stable Lifespan	Example
B	25,000 — 50,000	Blue	8 to 400 million years	Rigel, Spica
A	15,000 — 25,000	Blue-white	400 million to 4 billion years	Sirius, Vega
F	12,000 — 15,000	White	4 to 10 billion years	Delta Aquilae, Procyon
G	10,000 — 12,000	Yellow	10 to 30 billion years	Sun, Alpha Centauri A
K	7,000 — 10,000	Orange	30 to 70 billion years	Alpha Centauri B, Epsilon Eridani
M	below 7,000	Red	more than 70 billion years	Alpha Centauri C, Barnard's star

Supergiant stars such as Antares (class M) and giants like Arcturus (class K) are not main sequence stars. Therefore their stable lifespans in no way correspond with those shown on this table.

produced by the thermonuclear fusion reactions are making outward-pushing pressures that balance the inward-pulling gravity. The star shines with fusion energy, and it becomes a stable member of the great family of stars that astronomers call the main sequence. Its size and surface temperature will remain stable as long as hydrogen fusion provides the star's energy. The sun is about halfway through this stage.

3. The bigger and more massive the star was to start with, the hotter it "cooks", and the faster it runs through its hydrogen fuel supply. When the hydrogen runs low, the star begins burning the helium "ash" that is left in its core. Helium fusion, producing oxygen, neon and carbon, runs hotter than hydrogen fusion. The star's central temperature soars, and the outer layers of the star are forced to expand. The star is no longer a main sequence member — astronomers call it a red giant. Soon, in astronomical time scales, the helium runs low and the star begins burning the heavier elements in its core. The star continues to create, and then burn, increasingly heavier elements. All the while, the core is getting hotter and the star's outer envelope is swelling enormously. When the star goes into its red giant phase, it may become so large that it swallows its closest planest. The sun, someday a few billion years from now, may engulf Earth.

4. The eventual fate of the star depends on its original mass. A star of the sun's mass will probably end as a white dwarf, about the size of an Earth type planet. More massive stars could become 10 mile wide neutron stars, or even disappear from our universe altogether by becoming black holes.

The important point for us right now is that the star remains stable for only a certain finite period of time, depending on its original mass and temperature. After that, things get pretty desperate for any planet-dwelling life nearby.

Hot blue giants such as Rigel and Spica cannot stay stable for more than a few hundred million years. While this is long in terms of human lifespans, it is an eyeblink in terms of evolution. This means that such stars cannot be more than a few hundred million years old, at most. The dinosaurs never saw Rigel!

We know that it took about five billion years for intelligence to emerge on Earth. As a rule of thumb, lacking any better evidence, we can say that we should not expect to find intelligent life on planets circling stars that are less than a few billion years old. So Rigel and the other young blue giants can be ruled out as possible abodes for intelligent life.

The stars that are smaller and cooler than the

sun, such as the K and M dwarfs, have much longer life expectancies. But are they older than the sun? There is no easy way to tell. Moreover, since they are dimmer and cooler than the sun, the chances of their having an Earth type planet orbiting about them, at temperatures where water is liquid most of the time, are consequently smaller. This does not rule them out as possible habitats for intelligent life, but it makes the chances that much smaller.

There is another way to look at the problem of finding intelligent life in the Milky Way galaxy. Consider the geography of our galaxy.

The Milky Way is, of course, a spiral galaxy very much like the beautiful spiral in Andromeda. The core of our galaxy is thick with stars, but we can never see the core because it is hidden behind dense clouds of interstellar dust. Radio and infrared observations have been able to penetrate the clouds to some extent, but observations of the central regions of other galaxies show that they are so rich with stars that these stars are probably no more than a single light-year from each other, at most.

Stars in the core of a galaxy are also much older than the sun. Red giant stars are common there and, as we mentioned, stars become red giants only after they have ended their stable main sequence phases. Also, in the cores of galaxies there are no young, hot blue giants such as Rigel and Spica. These are found only in the spiral arms of galaxies.

Because the core regions of spiral galaxies seem to contain different types of stars than do the spiral arms, astronomers refer to the two different stellar constituencies as Population I and Population II. This sometimes causes confusion among nonastronomers.

Population I stars are the kind our sun lives among. These are the youngish stars of the spiral arms. Their brightest members are the blue giants. Population I stars contain a relatively high proportion of elements heavier than hydrogen and helium. Although the proportion of heavy elements hardly ever amounts to more than one percent, the Population I stars are said to be metal-rich.

Population II stars are found in the core regions of a galaxy. They are old; their brightest members are red giants, and they are mostly metal-poor.

The heavy-element content of a star is an important clue to its history. Why are the stars in a galaxy's core metal-poor and the stars in the spiral arms metal-rich? Because the elements heavier than hydrogen have been created inside the stars. It works this way:

Consider the Milky Way before there were any stars. Cosmologists have estimated that the Milky Way is between 10 and 20 billion years old; that is, some two to four times older than the sun. Presumably, the whole universe is the same age as the Milky Way. But when you are dealing with tens of billions of years, the numbers tend to become imprecise and hazy.

Regardless of the exact age of our galaxy, it began as an immense dark cloud of gas at least 100,000 light-years across. The gas might have been entirely hydrogen, or it might have been entirely hydrogen, or it might have been a hydrogen-helium mixture. Where the gas originally came from is a mystery that cosmologists argue about, but no one has been able to prove which side of the argument is correct — if either.

The first stars to form had no elements heavier than helium in them — perhaps nothing more than hydrogen. All the heavier elements, from lithium to iron, were "cooked" inside these stars as they went from hydrogen burning to helium burning to heavier-element burning.

Some of these stars exploded, in the last stages of their lives, with the titanic fury of the supernova. In those star shattering explosions, still heavier elements were created, beyond iron, all the way up to uranium and even beyond that. (There is evidence that the so-called man made element Californium 254, was present in the supernova of 1054 A.D. — which we know today as the Crab nebula.)

So the earliest generation of stars in the Milky Way began with only hydrogen — perhaps laced with a smattering of helium — and eventually produced all the heavier elements. And these stars threw the heavier elements back into space, where they served as the building materials for the next generation of stars. The explosions that marked the death throes of the first generation stars enriched the interstellar gas clouds with heavy elements. It was from these clouds that later generation stars were born.

Judging by the heavy-element content in the stars, most astrophysicists estimate that the sun must be a third generation star, grandson of the original stars of the Milky Way. The elements inside the sun today were once inside other stars. The atoms that make up the solar system were created in other stars. The atoms of your own body were made in stars. We are truly star children.

Beware of a clash of jargon when we speak about generations of stars and Population I or II. Population I stars are younger, late generation stars. Population II stars are the older, early generation stars. II came before I, historically.

What has all this to do with receiving visitors from the stars?

Artwork by Rick Sternbach

The sky is a dazzling canopy of stars for this planet of a Population II star near the center of the Milky Way. Heavy elements were so rare when planets were forming here that this planet, several billion miles from its sun, is merely a ball of ice. Nearer the star, hotter conditions may have boiled away all of its newly born planets 10 billion years ago. This makes life-bearing planets of Population II stars unlikely, and technologically advanced life virtually impossible.

Just this: Those first generation stars *could not produce life.* There was no carbon, no oxygen, no nitrogen — nothing but hydrogen and perhaps some helium. If those first stars had planets, they would all have been frozen ice balls of hydrogen — somewhat like Jupiter but not so colorful, because there would have been no ammonia or methane or any other chemical compounds to cause the gaudy streaks of colored clouds such as we see on Jupiter and Saturn. There wouldn't even have been any water. Not then.

Second generation stars? It's possible that they would have most of the heavier elements, including the carbon, oxygen, nitrogen, potassium, iron and such that we need to develop life. Planets of such stars might be able to support life, even our kind of life, if these heavier elements were present in sufficient quantities. If life has appeared on such planets, there's no reason to suppose it wouldn't eventually achieve intelligence. Certainly the long-lived red dwarf stars provide plenty of time for intelligence to develop — much more than five billion years.

Let us assume that an intelligent race could arise on the planets of a second generation star. Could such a race develop a high civilization and technology — high enough to build star-roving "chariots"? It all depends on the abundance of natural resources on the home planets. Fossil fuels such as coal and oil should be plentiful enough, since they are the result of the biodegrading of plant and animal remains. But what about metals? Our technology here on Earth is built around metals. Even our history rings with the sound of the Bronze Age, the Iron Age, the Steel Age, the Uranium Age.

Astronomical evidence is indistinct here.

Theory shows that second generation stars should have a lesser abundance of metals than we third generation types. But certainly there should be *some* metals on second generation planets.

How much metal is enough? There is no way to tell. Our own Jupiter probably has much more iron than Earth does. But it's mixed with 317 Earth masses of hydrogen, helium, methane, ammonia, and whatnot. The Jovians, if they exist, must find it much harder to locate and *get at* their iron than we do.

We should also realize that intelligence does not depend on heavy metals — but *life itself does!* There is an atom of iron at the core of every hemoglobin molecule in your body. Atoms of phosphorus are crucial to the energy-releasing chemistry in cells of living organisms. Chlorophyl is built around magnesium atoms. Without certain metals, life could not exist on Earth — or elsewhere.

Humankind rose to intelligence before our ancestors discovered heavy metals. They used wood, clay, rock and animal bones for their earliest technology. In a way, the human race went through a Ceramics Age before the discovery of metals. It was wood and ceramics that allowed primitive humans to handle and use fire. Only after fire was tamed could men begin to use metals on a large scale.

Human history shows that once metals were put into use, we took a giant leap forward. Metals allowed men to build effective plows. And swords. And chariots. Even today, our skyscrapers, computers, engines, spacecraft, weapons and household appliances are made mainly from metals. Metals are strong, tough and cheap. They are rather easily found and easily worked, even with low grade fire.

Could an intelligent race build cities and spacecraft without metals? Today there are many space age materials such as plastics and boron-fiber composites that are replacing some metals. But the machinery that produces them is made of stainless steel, copper, brass, etc. Modern technology is showing that there are nonmetallic materials that can outperform metals in strength, weight, and many other parameters. But these materials could not be developed before an extensive metal technology. Cavemen, or even the ancient Greeks, could not have produced boron-fiber composites or modern plastics. They did not have the metals to produce them with!

Would a metal-poor second generation intelligent race be stymied in its attempts at technology? Who can say? All we know for sure is that our technology certainly depends on metals, and until metals were available, our ancestors had no culture or technology higher than the Neolithic.

Another vital point: While we have nothing but the history of our own race to go on, it looks very much as if the whole world of electromagnetic forces would never have been discovered without metals such as iron and copper. The discovery of magnetism depended on the abundance of iron on this planet. And from the very beginnings of our experiments with electricity, we used lead, zinc, copper, brass, etc. It is difficult to see how the entire chain of the study and use of electromagnetic forces — from Volta and Faraday and Hertz through to radio telescopes and television and superconducting magnets — could have happened on a metal-poor planet. And where would technology be without electricity? Back in the early 19th century, at best.

It just might be possible for a metal-poor second generation intelligent race to build a complex technology completely out of nonmetals. But tribes on Earth that never had easy access to heavy metals have never developed a high technology. Coincidence?

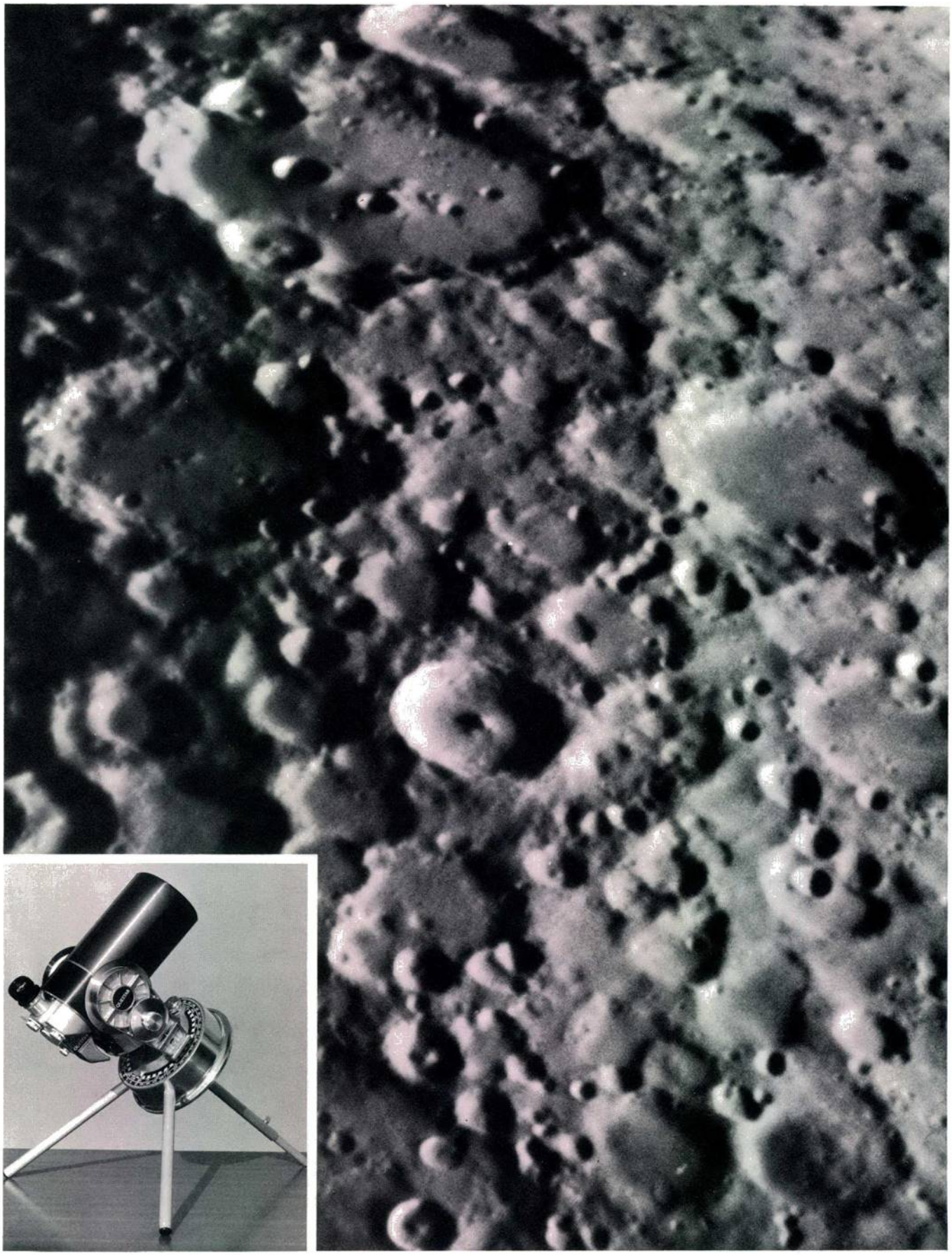
So there goes the long standing science fiction dream of an immense galactic empire, run by the older and wiser races of the Milky Way's ancient core region. Like the "steaming jungles" of Venus and the "desert cities" of Mars, the empire at the center of the galaxy simply does not exist. The first generation stars there produced no life. If there are second generation intelligences around they must be extremely rare and, because of their ages, *so* far advanced beyond us that empires are meaningless trivialities to them. Or, they are so metal starved that they are no doubt gamboling innocently through some version of Eden. They will never find us; we will have to find them. Hopefully, *we* will be old enough and wise enough to leave them strictly alone.

It's a shame. It would have been pleasant to talk with them — those incredibly ancient, benign, and understanding superbeings from the galaxy's core. It is sort of shattering to realize that, although life is probably common throughout much of the galaxy, highly advanced technological races are probably extremely rare.

One final note: The sun seems to be one of the oldest third generation stars in this part of the galaxy. There might not be any older races like us within thousands of light-years.

Could it be that *we* are the oldest, wisest, furthest advanced race in this part of the Milky Way? That we built the pyramids ourselves? That the only godlike chariots we will ever see will be the starships we build for our own flights through interstellar space?

Ben Bova is editor of **Analog Science Fiction/Science Fact.** *His recent books include* **Starflight and Other Improbabilities** *(see page* **45** *for review) and* **The New Astronomies,** *now a Mentor paperback.*



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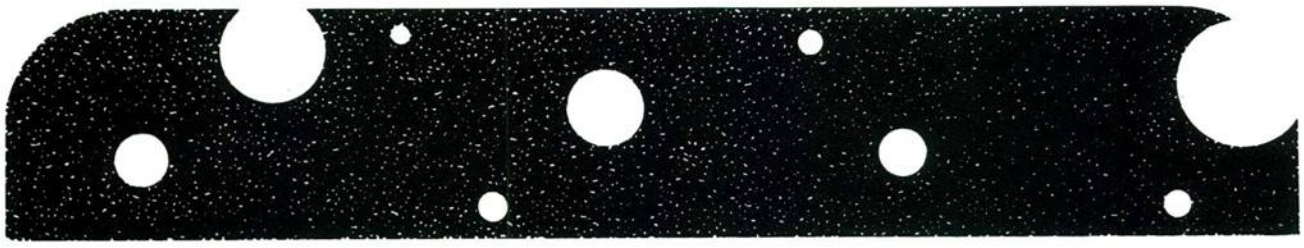


STELLAR FRONTIERS

The Search for Intelligence "Out There"

by
Gerrit L. Verschuur

The chances of picking up intelligent signals from beyond Earth seem so incredibly remote that those connected with the quest for such signals are faced with a multitude of dilemmas, the most awesome of which is the consequences of success. The first such search was conducted in 1960 — a time when powerful new radio telescopes brought some fundamental facts into focus.

Hydrogen, the basic constituent of the universe, "broadcasts" at 21cm, the natural wavelength of radio emissions from interstellar hydrogen atoms. Thus, it was reasoned, this would be the wavelength that other intelligent civilizations would use to transmit signals into space. These particular signals would be a beacon to other civilizations indicating the presence of intelligent life. This is basically the reasoning that has surrounded the few searches that have been conducted.

Of course we must stop and ask why any civilizaton would want to let anyone else know of its existence. After all, we are not contemplating such transmissions here on Earth. And even if we were, consider for a moment the probabilities for success. There are over one hundred billion stars in our galaxy. If 10 percent of those have life on planets orbiting them, and if one percent of those have intelligent life (two not unreasonable assumptions), we can be sure that most of them would be either far advanced or way behind us technically. Quite likely, very few civilizations would be at our stage of technological development. You can calculate your own probabilities here, but the chances of us stumbling on our 20th century counterparts is exceedingly remote.

Some recent estimates indicate the number of civilizations capable or interested in communicating with us is small enough to make our nearest neighbors at least 1,000 light-years away, if they are randomly scattered throughout our galaxy. Of course, if you consider the possibility that life on planets is seeded from other planets, then you could conjure up a picture in which the inhabited planets would lie in clusters in various areas of the galaxy. It also follows that each of the inhabited planets of one seeding would be at more or less the same stage of development at any time. The seeding hypothesis is pure speculation however.

All attempts to detect intelligent signals impinging on Earth have yielded no positive results. The first and most famous, or notorious, experiment was called project Ozma. The adjective depends on one's stand on the matter. And there are those who stand very firmly against experiments such as these. They argue that radio telescopes are in such short supply that the time on them should simply not be wasted on such wild experiments. They argue that in order to be a good scientist you should have a very clear idea of what sort of experiment you want to do. But when it comes to reasoning about how to search for signals from other civilizations, there is simply nothing to go on. You cannot be sure that anyone else would actually transmit, nor are you convinced where to look for such signals in the radio frequency band. And finally there is almost no way to tell which star harbors the inhabited planets. These uncertainties add up to a total lack of knowledge, and it can only be bad science to attempt the experiment — so the detractors say.

Then there are those who don't really care about such criticism, and they do try the experi-

U.S. Naval Observatory Photograph

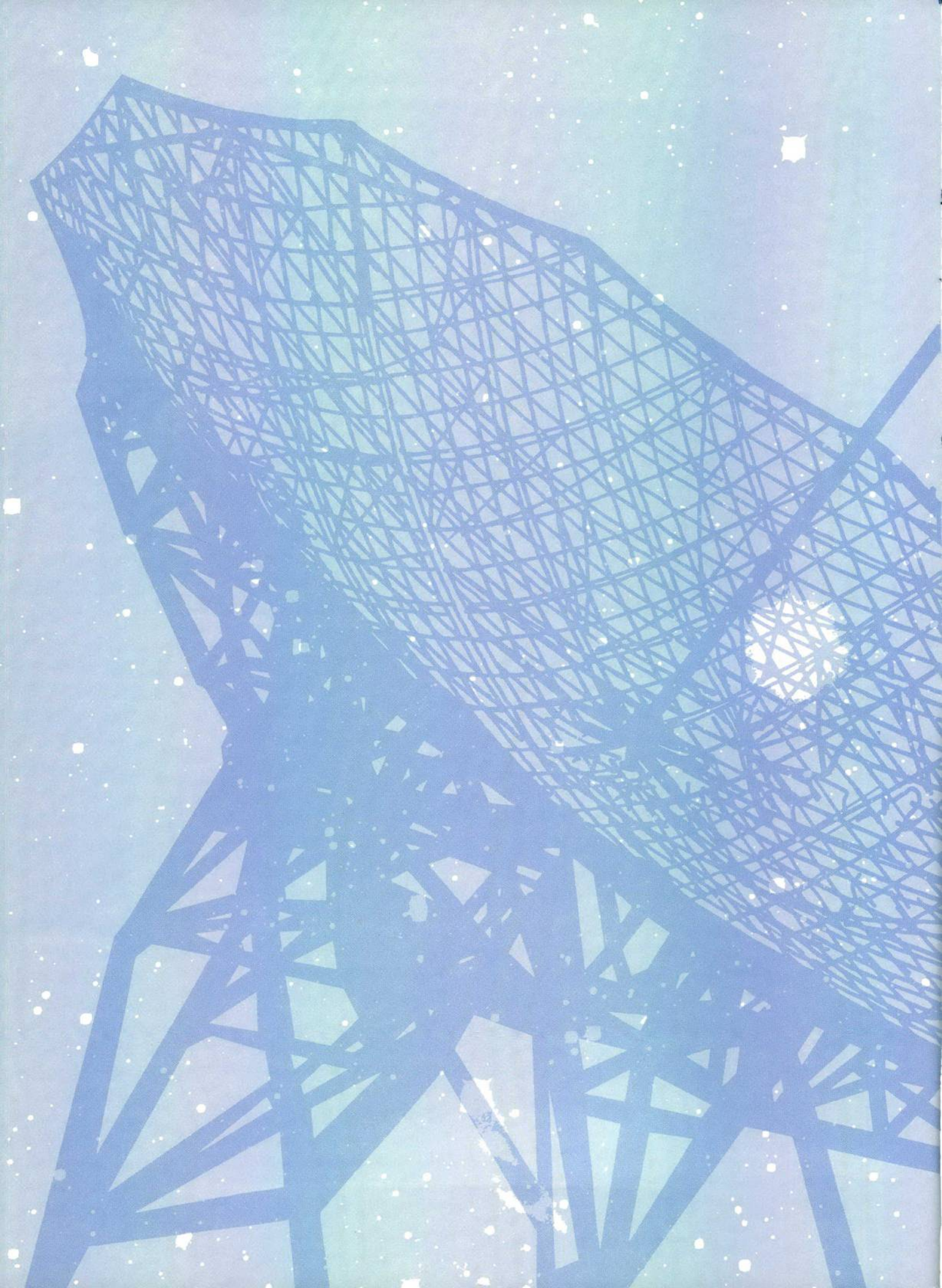
In every direction are millions of stars ranging from dozens to thousands of light-years away. This makes searching for possible intelligent signals from "out there" a formidable task. Where to search? This area of the sky in the constellation Andromeda is not a very crowded part of the galaxy.

Do any of these stars have inhabited planets? If so are they transmitting at us? Some astronomers estimate that a million stars will have to be listened to before we can expect success. M-31 (the Andromeda galaxy) is hazy patch to lower left.

ment. Of course, to get telescope time on one of the world's largest radio telescopes, you have to submit a well reasoned scientific justification for the experiment. And to do this for an experiment to search for intelligent life in space is, according to one scientist, like writing a justification about which side to start searching through a haystack to find the proverbial needle. Almost anything goes — but in the 1970s more things go in science if they are laced with heavy doses of mathematics.

So despite these barriers some early looks were sneaked in. I did some sneaking at the National Radio Astronomy Observatory but, of course, found nothing. Recently however, some official time was made available to me at that observatory where the 300 foot diameter radio telescope is ideal for such an experiment. It was equipped with two antennas and two receivers. This meant that one antenna could be pointed at the star in question and the other one pointed 20 minutes of arc away from it. If a strange radio signal was found coming from the direction of the star one could easily check to see whether the same signal was coming into the other receiver. If it was, then the signal was probably interference generated on Earth. If it was coming from a planet orbiting the star, it should only come in through one of the receivers.

Once again, not unexpectedly, nothing unusual was detected. But what if the experiment was successful? How would we handle that? How would the media handle it? Some of the incredibly bad reporting that has already brought the previous experiments such notoriety would mushroom. A positive detection of extraterrestrial intelligences through the signals they were transmitting would doubtless spur all the radio observatories of the world to drop what they were doing and monitor the signals as well. No doubt serious attempts to interpret the signals would be made very difficult by clamor from the media for more information. Perhaps such experiments would have to be carried out very quietly at first, to avoid a situation in which serious work would become impossible. This was the situation after pulsars were discovered by radio astronomers in England. They kept it a secret for months while they tried to think of an explanation which was more scientifically rea-



sonable than the "little green men" hypothesis that seemed possible at first.

Any remotely "positive" results from searches would involve a lot of follow-up work to check the results to make sure that the signals couldn't be explained by any natural means. This must be done *before* announcing the findings. The time between these last two steps could be years, because theoretical astrophysics has a remarkable ability to explain almost anything bizarre that is found out there. Witness the quasars, pulsars, molecular masers and a host of other recently discovered phenomena in space — not the least of which are X-ray stars and black holes. Indeed, the detection of other life in the universe might well come through astronomical discoveries which are made and at first explained in apparently reasonable ways; but then as more and more data is accumulated these discoveries might become more and more impossible to describe in terms of naturally occurring phenomena. Finally a time would be reached when only an artificial explanation for the source of the radiation would work.

In my particular experiment, a long time was spent simply tracking a few stars in order to state that no signals on the order of one megawatt of power were being transmitted from a 300 foot diameter radio telescope orbiting any of the 10 stars examined. These included the nearby stars Tau Ceti, Epsilon Eridani and Barnard's star. At the time, Barnard's star was thought to have at least two planets orbiting about it; but nothing is sacred in astronomy, and doubt has been cast on that conclusion by other experimenters. In any case, if there had been a transmitter of only 600 kilowatts of power beamed at Earth from a planet orbiting Barnard's star while it was being observed, these signals could have been detected.

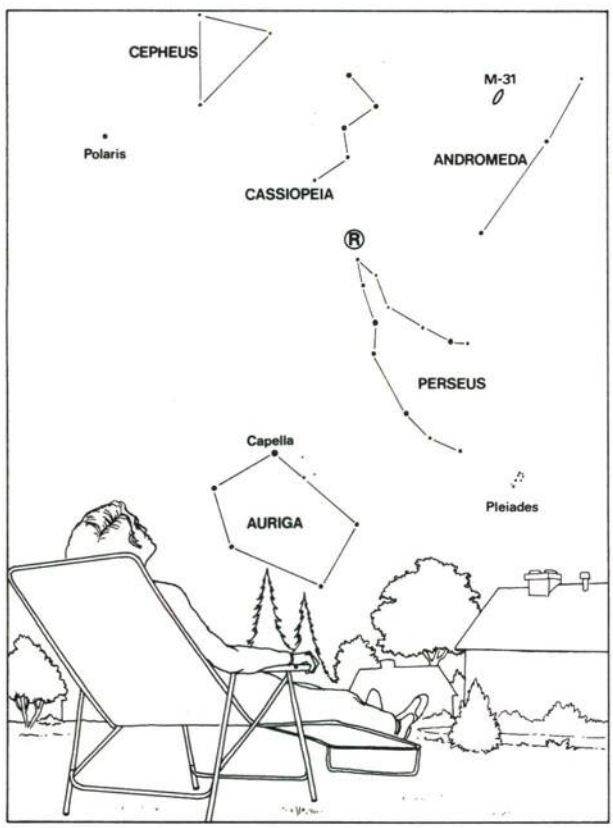
Another group has recently completed a more extensive experiment but has not yet published the results. While it is probable that their experiments were negative, perhaps they are waiting to gather all their data together since they made many observations. Presumably we will learn that none of the nearest several hundred stars are sources of possible signals beamed at Earth from civilizations in orbit about them.

By at least bringing the experiments out into the open and having now had some otherwise reputable astronomers involved in them, we have entered a new era in which the obvious work has been done and in which other astronomers might feel less threatened when they want to perform similar experiments.

According to the most educated guess, the nearest civilizations with whom we could possibly communicate are at least 1,000 light-years away. But what if we were to pick up signals from them? First of all those signals are really unlikely to be beamed deliberately at us. Our experiments so far have in fact only searched for signals deliberately intended for us. How geocentric! How pompous! We are far more likely to pick up signals not meant for us and from a very distant civilization at that. What do we do then? Transmit back at them? They wouldn't even know we had picked up their signals — and it might take 500 years for our signals to reach them and another 500 years for them to answer. Our civilization is certainly not stable enough for us to keep it sufficiently together for 1,000 years or more to follow through on such an interstellar telephone call!

But someday, maybe soon, someone will find something. The search is inevitable since this particular discovery will answer the great question — we will finally know that we are not alone!

THE MONTH OF METEORS



Artwork and diagram by Victor Costanzo

About 20 minutes worth of Perseid meteors are superimposed in this rendering of an astronomy enthusiast enjoying the best meteor shower since 1972. He is facing northeast toward the area where the meteors seem to originate — a zone called the radiant (marked with a circled "R" above). Constellations are as they appear at about 1 a.m. daylight time in mid-August.

It's happened to everyone at one time or another. You just happen to glance up at the star filled sky — perhaps only for a second — and suddenly this placid view is sliced by the brilliance of a falling star. The expression "falling star" is just a description of what appeared to be happening; the object that flashed across the sky and quickly disappeared is properly called a meteor.

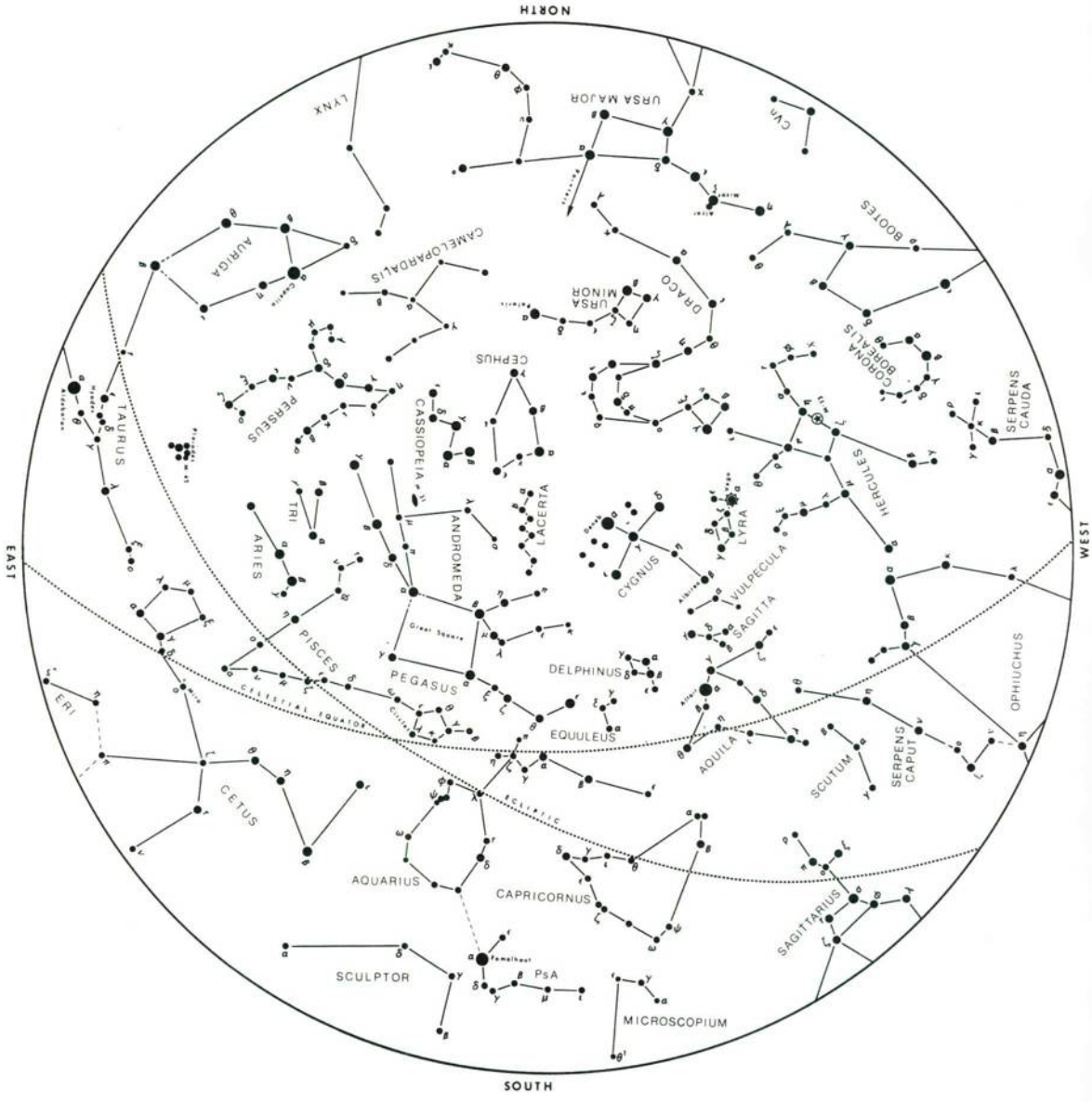
Meteors actually have nothing to do with stars. They are tiny bits of space debris, so small that 1,000 would easily fit in the cupped palm of your hand. Yet each one of them causes that familiar brief but brilliant flash in the night sky as it ends its existence in a 50,000 m.p.h. plunge into the top layers of our atmosphere. At that speed, friction with upper air particles vaporizes the average meteor in 1/2 second. It is this vaporization process that produces the brilliant flash of light.

Normally Earth collects 40 tons of meteoric material each day. Most of it produces meteors too faint to be seen with the unaided eye. On the average you can count on three or four fairly bright meteors per hour during the evening hours, with the rate rising to 10 per hour by dawn. However at quite predictable intervals, as Earth navigates its annual orbit around the sun, it encounters swarms of meteoric material. These swarms are believed to be the remains of disintegrated comets and are located at specific points in Earth's orbit. Like mileage posts on a race track, the meteor swarm is rapidly encountered and soon left behind. The result is a meteor shower lasting a few nights at most.

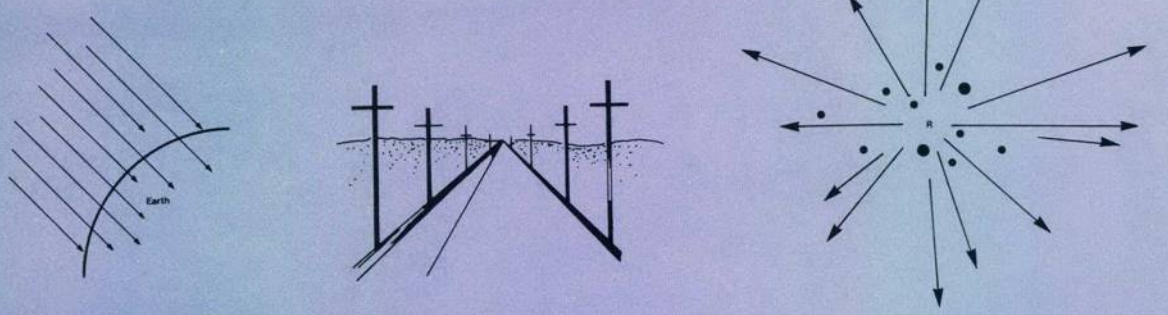
This month the most reliable of all predictable meteor displays, known as the Perseids, is due in the late evening and early morning hours of Aug. 11-12 and again the next night, Aug. 12-13. The Perseids are named for the constellation Perseus from which the meteors seem to radiate.

Normally the Perseids produce an average of nearly one meteor per minute between midnight and dawn, but this year the light from the last quarter moon will interfere. Moonrise is about midnight on the night of Aug. 11-12 and 1 a.m. the next night. Even though the moon rises during the peak hours of the shower, all is not lost. The moon will just be a "fat" crescent and therefore only three or four percent as bright as it is when full. If you can keep it hidden behind a tree for a while you can add an hour or so to your meteor watching.

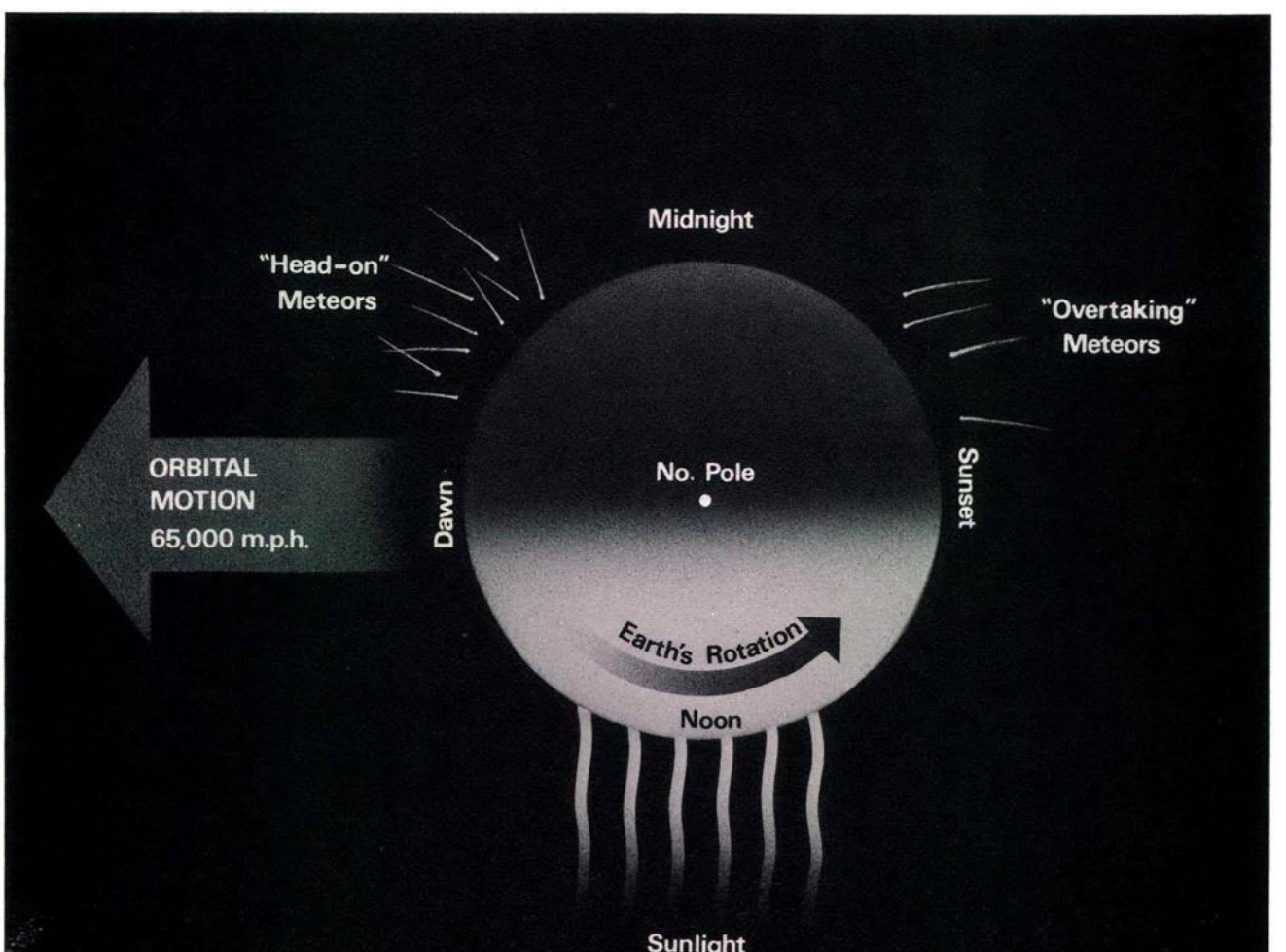
Eventually the moon will win and largely spoil the fun by swamping out the fainter meteors. Although the shower will not be quite as strong on the morning of the 13th, moonrise is later and the crescent thinner; so good conditions will hold probably until 2 a.m. — an hour longer than the previous night. Your plan should be to begin serious



This map shows sky in mid-August at about 1 a.m. daylight time; it is for use in constellation identification during the Perseid meteor shower.

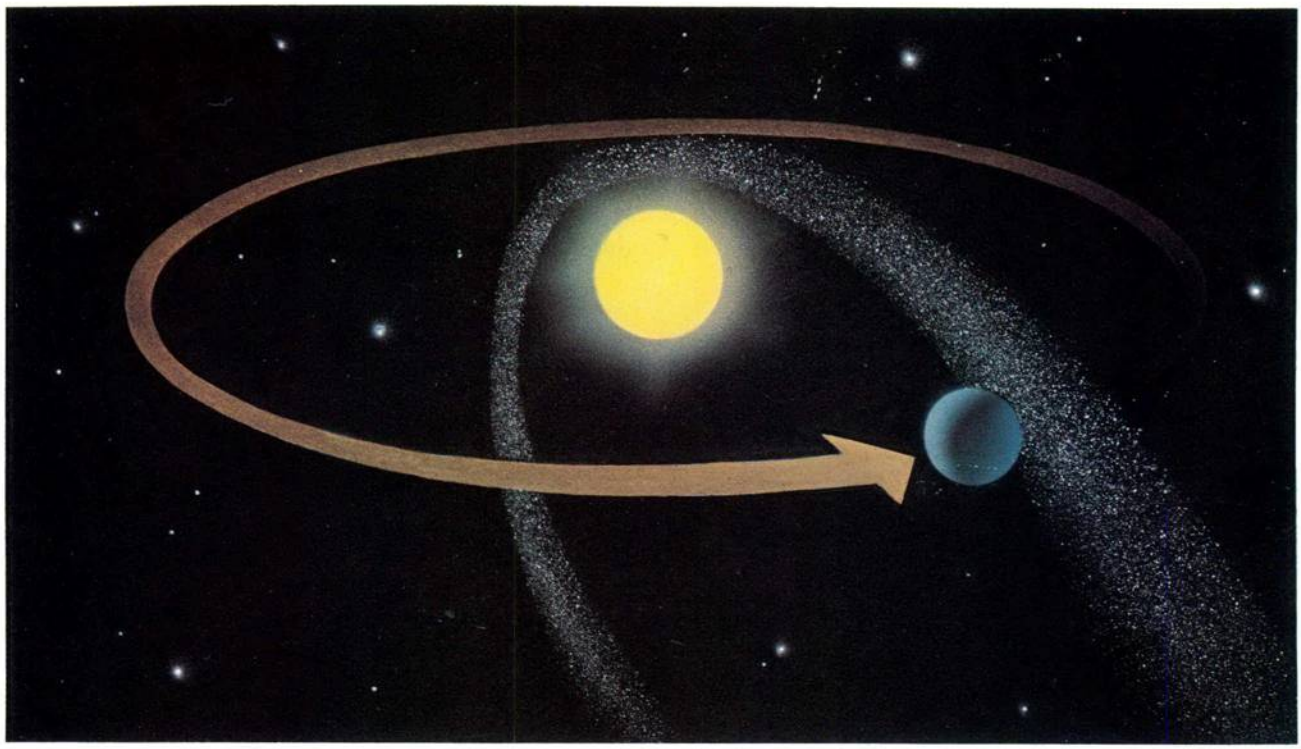


Meteors plunge into Earth's atmosphere in parallel paths during a meteor shower (left). But from our viewpoint on the surface of our planet they seem to diverge from a radiant point just as a highway vanishes to a point when viewed on flat terrain. The radiant of the Perseids is in the constellation Perseus — hence the name.



Meteors are always more frequent after midnight than before because the "a.m." part of our planet is facing the same direction as its motion in its orbit. It is similar to the effect one gets during a walk in a heavy snowfall. After a few minutes the front of your coat is plastered with snow (even if there is no wind) while your back is only lightly peppered with flakes. This is of course due to the effect of walking into the flakes. Earth does the same as it pursues its orbit at a consistent 67,000 m.p.h. The side "facing" the meteors is the midnight to dawn side so more meteors are seen during those hours.

Diagram by Victor Costanzo



Artwork by Victor Costanzo

Meteor swarms that produce showers are believed to be debris scattered uniformly along the orbit of a disintegrated comet. Earth's orbit around the sun (arrow) intersects the Perseid swarm around Aug. 12 each year.

watching around 10:30 p.m. on Sunday (the 11th) or Monday (the 12th) evenings and keep watching until the moon is clear of all horizon obstructions. Don't expect one meteor per minute — that's the peak output and occurs during the daylight hours on Monday, the 12th. About 30 per hour around midnight is the best we can hope for this year.

Experienced meteor watchers use lawn chairs that adjust to a nearly horizontal position so that almost the entire sky is comfortably in view. Select the darkest site possible and face generally northeast so the constellation Perseus is in front of you. Remember to supply yourself with blankets and insect repellent. Try to talk some friends into staying up with you so you can share what at first, to some nonastronomy types, may seem to be an odd activity. Because meteor observing is best done with no telescopic equipment it is an ideal way to introduce sky phenomena to others. (Meteors not quite in the main stream can be seen a few nights before or after Aug. 12.)

Despite the fact that several dozen meteors per hour may be observed at the peak of this shower under favorable circumstances, the average distance between individual meteors is over 100 miles. So even within a meteor "swarm", space is relatively empty.

Meteor observing has several side benefits: It's relaxing and gives you an opportunity to learn a few more constellations; that's why we included the early morning sky chart. But the most popular aspect of meteor watching is that it is best done with your eyes alone. Binoculars or telescopes are extra baggage because of their far smaller field of view than that of the eye alone. Since meteors seem to dart from practically anywhere you almost need eyes in the back of your head!

If you care to try an interesting experiment, have the chart on page 26 beside you and a heavily filtered flashlight handy. (A bright light will spoil your "night vision" so keep it as dim as possible.) Also have a colored marking pen or pencil with you. When you see a meteor, carefully note its starting and ending points among the constellations. Then plot the path on the map with an arrow to indicate direction of flight. Tracing all the lines backward will take you to the radiant point in Perseus. If any meteors don't seem to radiate from this point they are among the few sporadic meteors seen on a normal night.

In case you are wondering, no Perseid meteor has ever been known to reach Earth's surface. Even those as bright as Venus are quickly consumed, but often leave a glowing trail that may last for several seconds. You can expect one or two such treats during this shower. Much additional information about the Perseids and meteor observing is contained in this month's Photography in Astronomy. Even if you don't plan to try photographing this event, that article is useful reading.

So have fun. And tell us your reactions — especially if you have never tried meteor observing before.

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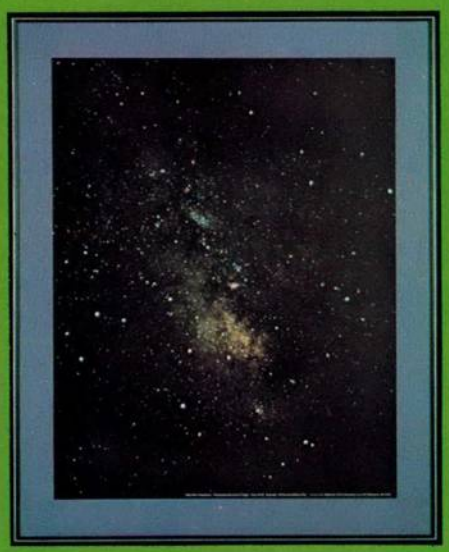
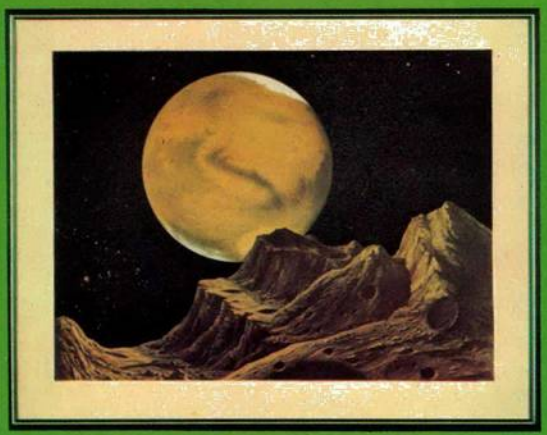


Milky Way in Sagittarius

The detailed cover photograph of ASTRONOMY's March issue is now a colorful, 17 x 22 inch blow-up poster. A host of celestial objects at our galaxy's core are recorded in full color in this breathtaking photograph by Orien A. Ernest. The gossamer, golden beauty of the Sagittarius star clouds is revealed in magnificence unsurpassed by any other color Milky Way photograph. This beautiful lithograph is available framed as above or unframed.



Mars as Seen From Deimos

The artistic imagination of Victor Costanzo is boldly displayed in this 17 x 22 inch full color lithograph of the red planet Mars as it would appear from its outer satellite Deimos. Costanzo's painstaking accuracy in this rendition is given further credence because he incorporated real constellations in the sky background. To the lower left of the planet is the Hyades star cluster in Taurus, and to the upper right is the constellation Aries. This artwork was first used as a two page spread in ASTRONOMY's May issue to illustrate "The Lost Pictures of Mars" by Carl Sagan. It is available framed as above or unframed.

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PHOTOGRAPHY IN ASTRONOMY

Catch a Falling Star

by

Ronald A. Oriti

Of all the various types of astronomical photography, meteor photography is the nearest to being called a sport. It is, in fact, rather like fishing. You throw out your line and wait for a strike. The catch can be big or small or nothing at all. You may use the finest professional equipment and still catch nothing, while the kid with the inexpensive gear hooks the big one. So it is with meteor photography. Anyone can participate; skill is a help, but not nearly as much as is luck.

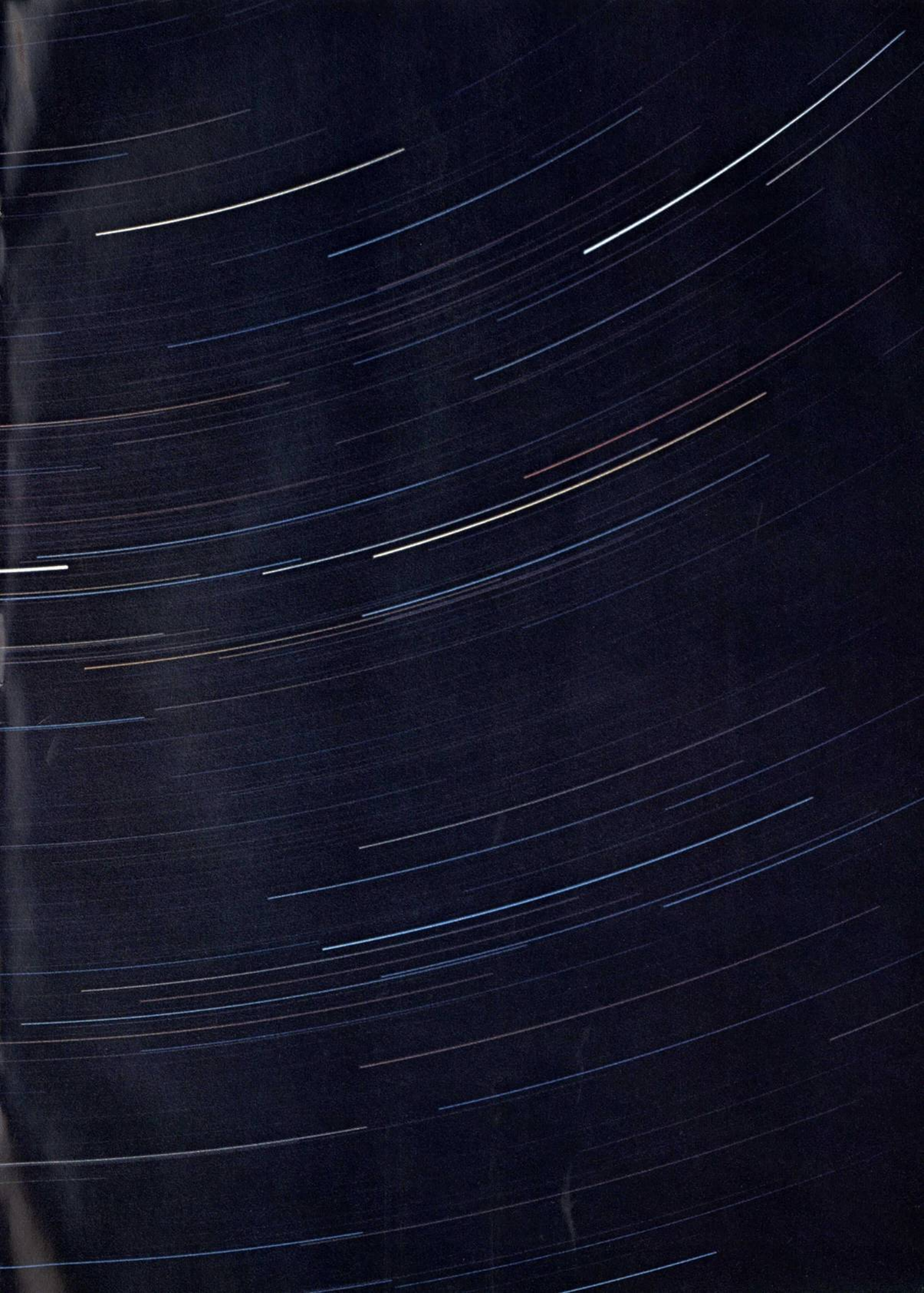
The minimum equipment for meteor photography is nothing more complicated than a camera and tripod. An ordinary 35mm camera with a focal length of about 50mm and a focal ratio of f/2.8 will work quite well. Better still is a "fast" lens with a smaller focal ratio. (An f/1.4 lens collects four times as much light as one of f/2.8). Since a meteor can flash across almost any part of the sky, a camera with a large field of view increases your chance of success. However, the larger the field of view, the smaller the meteor trail recorded on the film. Just as a house or tree appears smaller through a wide angle lens, so does a meteor trail — and faint meteors don't get recorded at all.

Another difficulty with the many wide angle lenses is that they squeeze a large portion of the curved sky onto a flat piece of film, producing unwanted distortions. The ordinary 35mm camera with a lens of slightly shorter focal length than the standard 50mm is an excellent compromise. It gives a relatively large field of view without serious distortion. A fisherman may increase his chances for success by using two or more rods, or by adding multiple lures and hooks to his line. Similarly, the meteor photographer can increase his chances by using several cameras, each on its own tripod or mounted together as one large unit. The individual cameras should be adjusted so that their fields of view slightly overlap. When a group of meteor photographers and observers

---

Centerfold Photograph by Ronald A. Oriti

A Perseid fireball meteor brighter than the planet Venus lit up the skies over southern California on Aug. 12, 1972. The f/2.8 camera was aimed at the constellations Andromeda and Cassiopeia during the exposure. The meteor's trail lasted about five minutes. The film used was High Speed Ektachrome, force processed to ASA 400.



get together, they should be certain to co-ordinate their efforts by insuring that no two cameras point at the same place in the sky (unless, of course, they are purposely comparing the ability of one camera or film type with another).

When choosing film, one must decide between fast (more sensitive) black and white film, or slow (less sensitive) color film. Each type has its advantages and disadvantages. Black and white film enables you to catch more meteors but the results will lack the beauty of a color picture; furthermore, the black and white film does not record the color of the meteor, which often is of interest. For example, the color photograph of a Perseid meteor on page 32 shows the meteor to have a reddish color where it first begins. Gradually as the temperature rises, the meteor's color becomes orange, then yellow, then white, and finally blue. The bursting of the meteor, which produced a couple of knots on the forward spike, occurred when the color was blue and the temperature highest.

Probably the best black and white film readily available to the amateur is Kodak Tri-X Pan, ASA 400. (The ASA rating indicates how sensitive or fast the film is.) When you have the film developed you can request that the film be kept in the developer longer in order to increase its sensitivity and raise its ASA rating. This process, called pushing, can boost the ASA of Tri-X to 800 or 1,000, or even higher. However, pushing the development results in increased graininess, and you eventually reach the point of diminishing returns.

The best color film readily available is probably Kodak's High Speed Ektachrome, ASA 160. With pushing, the ASA of High Speed Ektachrome can be increased to 400 (at extra cost). Another color slide film that offers good results is GAF 500, which is slightly faster — but grainier — than High Speed Ektachrome.

Once you have chosen your film and camera, all you need is an ordinary sturdy camera tripod. With this method you simply point the camera toward some point in the sky, open the shutter, clamp the trigger release, and take a time exposure which ranges from 15 minutes to an hour (depending upon sky brightness and the kind of film used). When the film is developed you will immediately notice that the daily motion of the stars will have caused them to produce streaks on the film. If the camera is pointed toward the celestial equator, the streaks will be parallel and straight. If it is pointed near the celestial pole, the streaks will be parts of concentric circles. At other places in the sky, streaks showing varying degrees of curvature will be seen. The longer the exposure, the longer the star trails will be. If you capture a meteor, the trail it produces will usually cross the star trails. If the meteor trail is faint and parallel to the star trails, it may be overlooked in a cursory examination of the film.

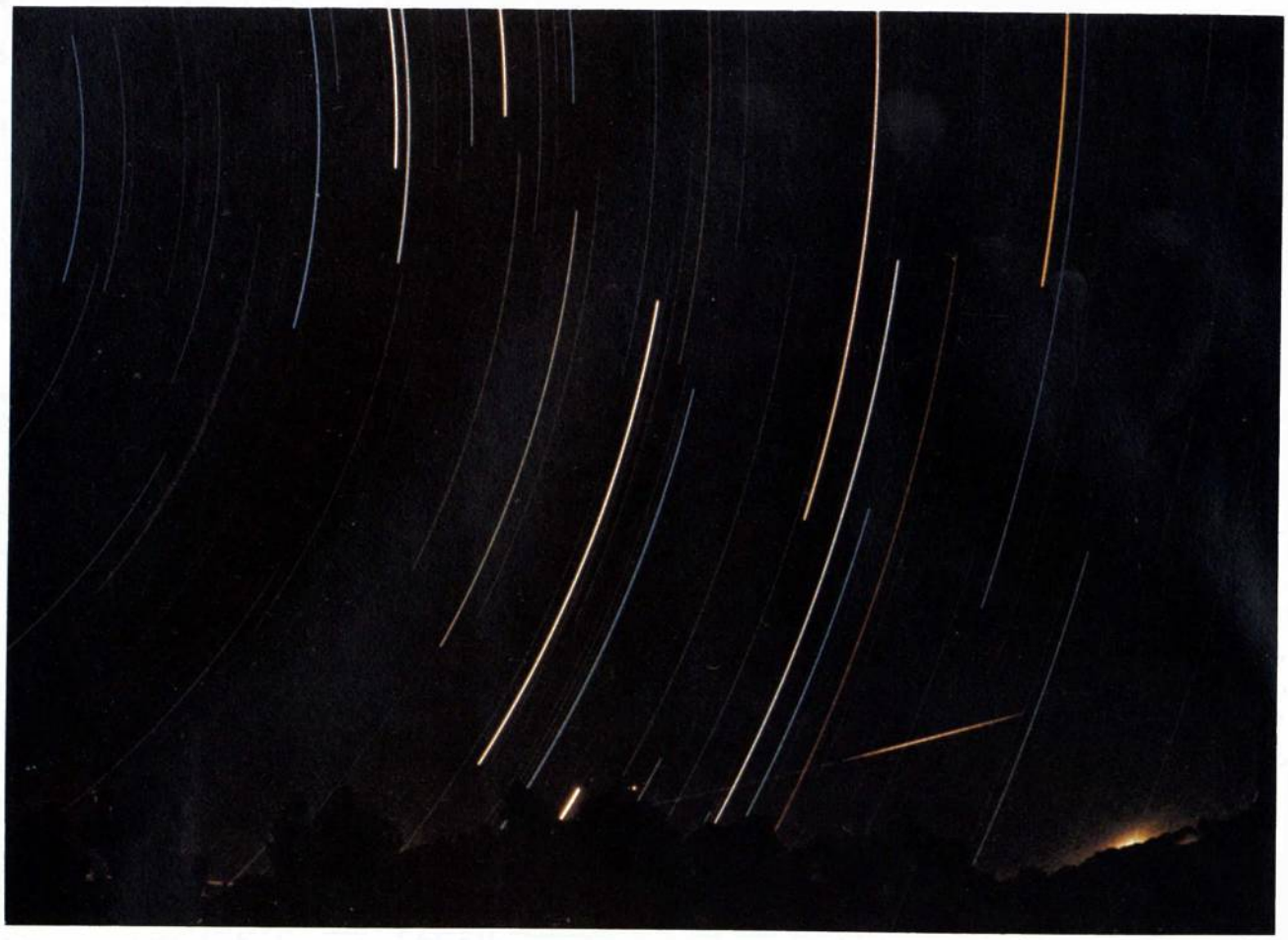
A still better method, which is usually unavailable except to the more serious enthusiast, is to use an equatorial mounting and a clock drive which enables the camera to follow the stars. This results in the stars appearing as points of light and thus individual stars are more easily identified. In practice it often turns out that the mounting is improperly aligned or the camera improperly guided, so that the stars actually show up as very short streaks. Such a photo is still more valuable from a scientific point of view, than one taken without a clock drive; but from an esthetic point of view it is less satisfactory, because it gives the impression that the stars are out of focus. However, there is no question that this method, when carried out properly, is the superior of the two.

A useful accessory device is the rotating shutter, which is placed in front of the camera lens and causes the meteor trail to be interrupted at some predetermined interval — usually 10 to 60 times per second. The meteor trail becomes a series of short segments from which it is possible to determine the meteor's angular velocity. The true velocity in miles per second can be computed only if we also know the true path of the meteor through the air. This can be obtained from photographs of the meteor taken from two different locations separated by from 10 to 30 miles. The parallax resulting from this separation of the cameras enables the investigator to use simple trigonometry to calculate the distance to various points on the meteor's trail. This is an excellent project for members of an astronomy club.

A good fisherman knows that the fish bite more readily in the morning and early evening, and are less active in the middle of the day. In the same way a meteor photographer must know at what times he is most likely to catch a meteor. It is a waste of time to attempt to photograph meteors on a night picked at random. While sporadic meteors may be seen every night, they are so infrequent (5 to 10 per hour), and their place of appearance so unpredictable, that one may spend literally hundreds of hours photographing the sky without recording a single meteor.

The odds change greatly in favor of the photographer, however, during a meteor shower. Some meteor showers produce several thousands of meteors per hour. Unfortunately, such showers occur only a few times in a century, and so we must be content with the less spectacular but more dependable yearly showers — the finest of which is the Perseid shower, occurring every year around Aug. 12 as described in Gazer's Gazette this issue.

Photograph by John Sanford



Photograph by Ronald A. Oriti

A Perseid meteor skims the horizon just before moonrise. Color meteor photography is one of the least difficult endeavors for the astrophotographer but it can (if you are lucky) be exceptionally rewarding.

The Perseid shower produces about 50 to 60 meteors per hour at its peak, some of which are brilliant fireballs. This is perhaps the most photographed of all showers, for it occurs at a time when the nights are not too cold to discourage the photographer. You will find that the Perseids will put on a better display during the period from midnight to dawn when the constellation Perseus is well above the horizon.

Meteors from a shower such as the Perseids may be seen almost anywhere in the sky, but one finds that when the trails are traced back toward the direction from which they came, they all meet in a small area at the northern end of the constellation Perseus. This small area is known as the radiant point. Shower meteors appear to come from a radiant point because the particles which produce the meteors move together as a swarm in space, and they enter the atmosphere from essentially the same direction. They diverge from this direction in the same way as railroad tracks diverge from a distant point. They are really moving parallel to each other, and it is a result of our perspective that they appear to diverge.

Meteors which appear exactly at the radiant point are actually traveling directly toward the observer, and therefore appear as momentary points of light which quickly come to maximum brightness and then fade away. Because such meteors produce no trails, they are referred to as stationary meteors. As one moves away from the radiant, the meteors tend to be moving more nearly across the observer's line of sight. The farther one looks from the radiant, the faster the meteors appear to be going — and the faster the meteor, the shorter the time its light will be striking the film. As a consequence you should avoid aiming your camera directly at the radiant, where the meteor trails are very short. Also avoid areas very far from the radiant where the trails may be too long to fit on the film, and where the meteors — by virtue of their greater speed — appear less bright. As a compromise, point your camera toward any place where the radiant is about 5 to 15 degrees outside the field of view.

You will probably want to ignore those nights

when the moon is full, or nearly so. The brighter sky on such nights will cut your exposure times significantly, and will reduce the film's ability to record fainter meteors. A lens shade should always be used in order to keep out unwanted light — from automobile headlights, streetlights, or other unavoidable annoyances.

When setting up for your first exposure of the night, be absolutely certain that the camera's focus is set on infinity, and that the lens is fully opened to the smallest f/stop number. The shutter should be set on B so that a long time exposure can be made. Don't make the mistake of leaving the lens cover on the camera. Be gentle when clamping or unclamping the trigger release or you will put a wiggle in your star trails at the beginning or end of the exposure. You may wish to interrupt your exposure for a few seconds shortly after it begins, and shortly before it ends. This results in two small breaks in the star trails. These breaks provide better reference points than the ends of the trails. If you make one of the interruptions closer to the beginning or end of the exposure than the other, it is easier to tell which end of the star trail is at the beginning of the exposure.

Photograph by John Sanford

While photographing the loose collection of stars in Auriga known as M-34, an unexpected (as they always are) meteor flashed across the field leaving its fiery portrait on the film. Sometimes such intrusions are considered annoying by serious astrophotographers.

Photograph by Patrick Michaud

During a guided exposure of the Milky Way in northern Sagittarius, a brilliant meteor unpredictably flashed to its destruction in the upper atmosphere — a speck of dust that, for a moment at least, masqueraded as a falling star.

Be sure to keep a notebook so that you can record the times at which your exposure begins and ends, the stars toward which your camera is pointed, the apparent magnitude of any meteors you photograph, and any other noteworthy or unusual phenomenon which occurs. A flashlight with a red filter will come in handy for this purpose.

In general, the more hours spent photographing the sky, the greater the chance is of getting a good meteor photograph. When you finally get that big one, you will find any number of magazines — including ASTRONOMY — that will be interested in publishing your picture. Afterward you may be unable to resist the temptation to have it mounted and placed on the wall. You can tell your friends with pride, "Here's the one that didn't get away!"

Ronald A. Oriti is a staff member of the Griffith Observatory, Los Angeles. His special interest is meteors and meteorites.

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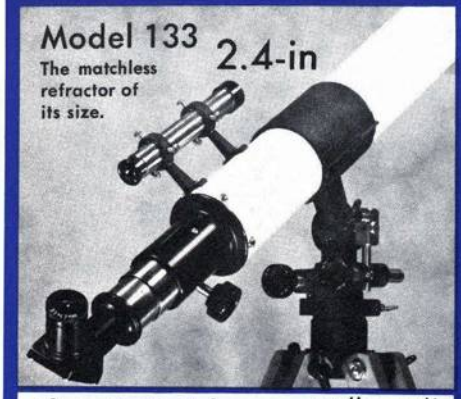

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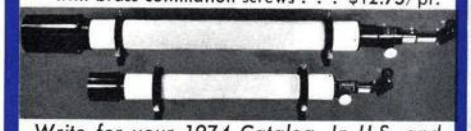

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ASTRONOMY

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In response to requests from our readers and schools, ASTRONOMY has just published a cumulative index to Vol. 1. This subject index covers August, September, October, November and December, 1973, which includes issue Nos. 1 through 5. Index to Vol. 1 is available for $1.00 each, including handling and first class postage.

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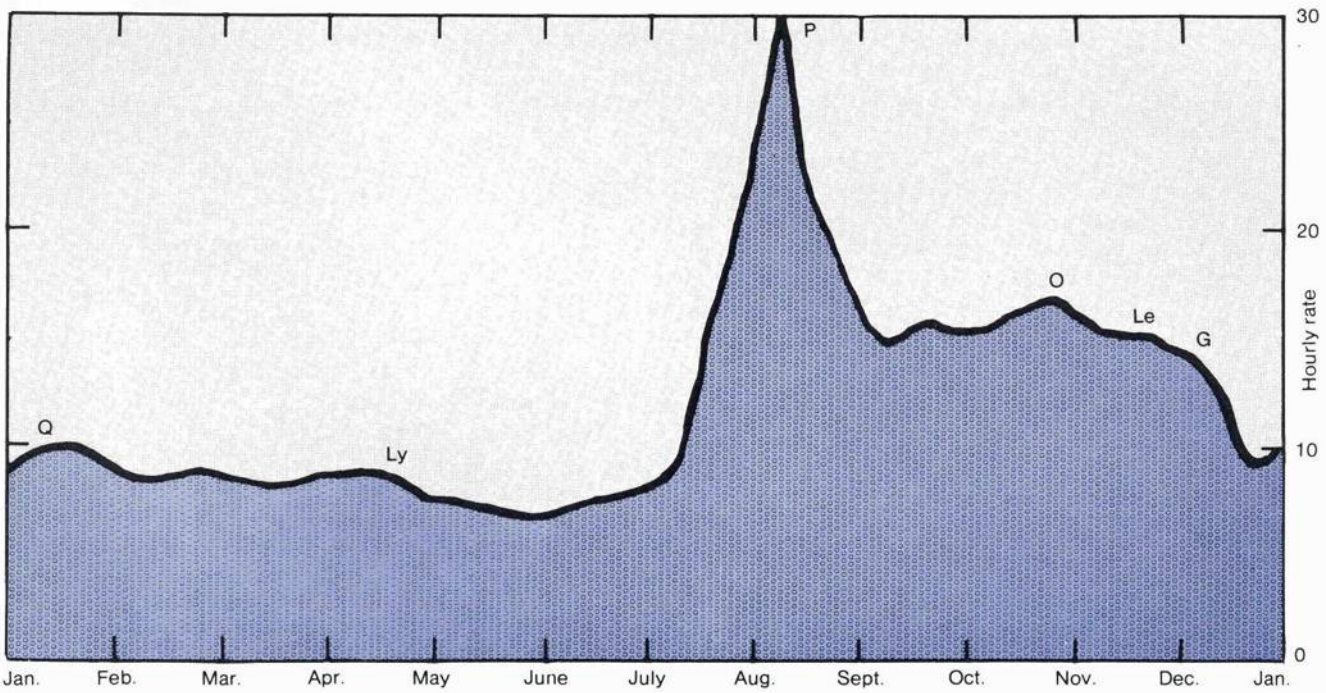
Giant and Midget Planets in August Skies

Late summer is the perfect time for sky watchers. The weather is usually accommodating, and the sky is filled with interesting objects all awaiting the searching eye of the backyard astronomer. But from one summer to another the sky changes somewhat depending on which planets are visible. This summer we have only one but it's the most interesting one — the giant Jupiter. Added to that we have a minor treat — the baby planet Ceres — the largest and second brightest of the asteroids. Perhaps most significant is the annual celestial fireworks known as the Perseid meteor shower.

Perseid Meteors

The best display of meteors since 1972 is due the early mornings of the 12th and 13th. Conditions are fairly good for observing this year as detailed in this month's Gazer's Gazette. The average number of meteors visible varies throughout the year with a definite peak in August due to this rich shower (see chart below). Sometimes



The number of meteors you can expect to see per hour (hourly rate) varies throughout the year. Significant meteor showers add to the base of six or seven sporadic meteors per hour that are always zipping into the atmosphere. The showers labeled are: Q = Quadrantids; Ly = Lyrids; P = Perseids; O = Orionids; Le = Leonids; G = Geminids. This plot is for very dark skies. Far less meteors are visible from urban locations.

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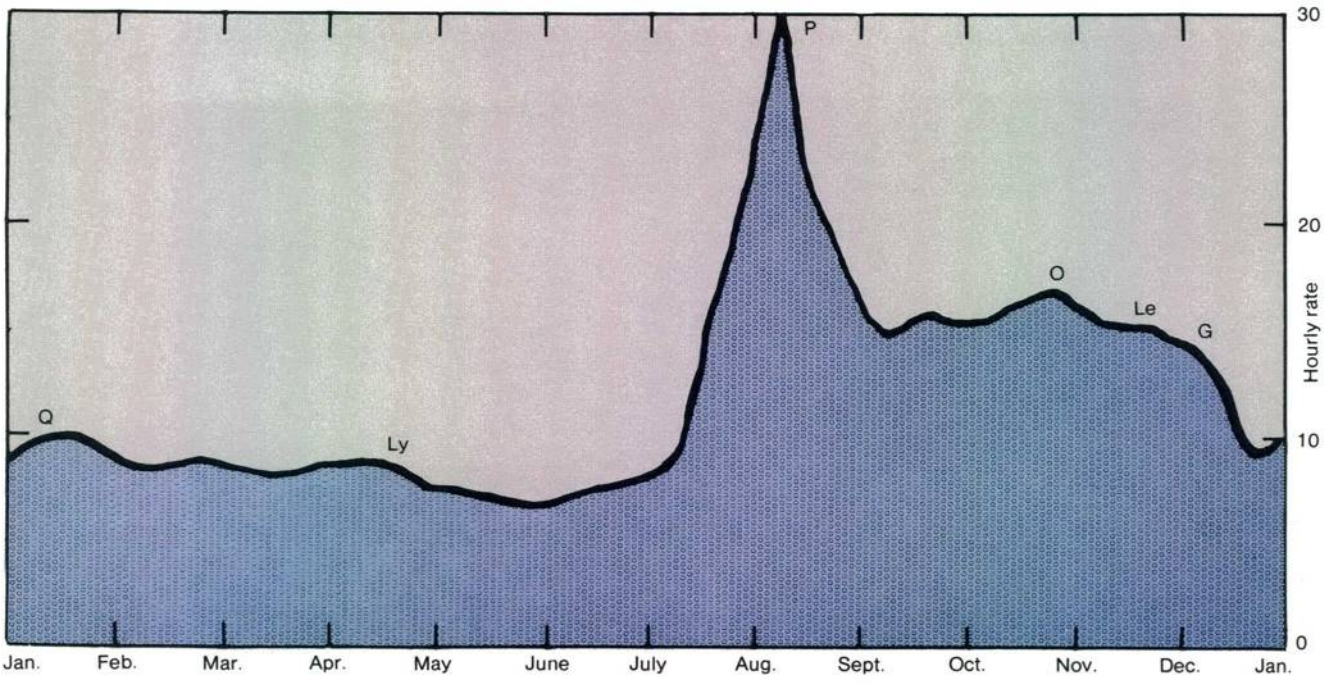

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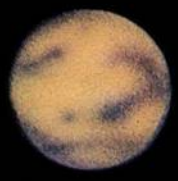


Ⓒ Ceres

Aug.	1	15
R.A.	23h22m	23h15m
Dec.	-19°39'	-21°17'
Mag.	+7.4	+7.3

Ⓐ Mercury

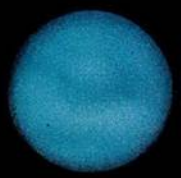
Aug.	1
R.A.	7h42m
Dec.	+21°30'
Dia.	too near sun
Mag.	too near sun

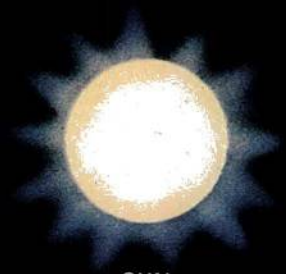
Ⓑ Mercury

Aug.	15
R.A.	9h37m
Dec.	+16°04'
Dia.	too near sun
Mag.	too near sun

Ⓜ Mars

Aug.	1	15
R.A.	10h23m	10h56m
Dec.	+11°15'	+7°53'
Dia.	too near sun	too near sun
Mag.	too near sun	too near sun



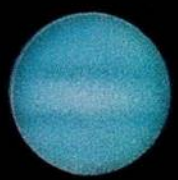


SUN

The sun is within the stippled zone throughout the month. Planets and stars near this area are not easily seen.

Ⓢ Saturn

Aug.	1	15
R.A.	6h54m	7h01m
Dec.	+22°19'	+22°10'
Dia.	16.8"	17.0"
Mag.	+0.3	+0.4

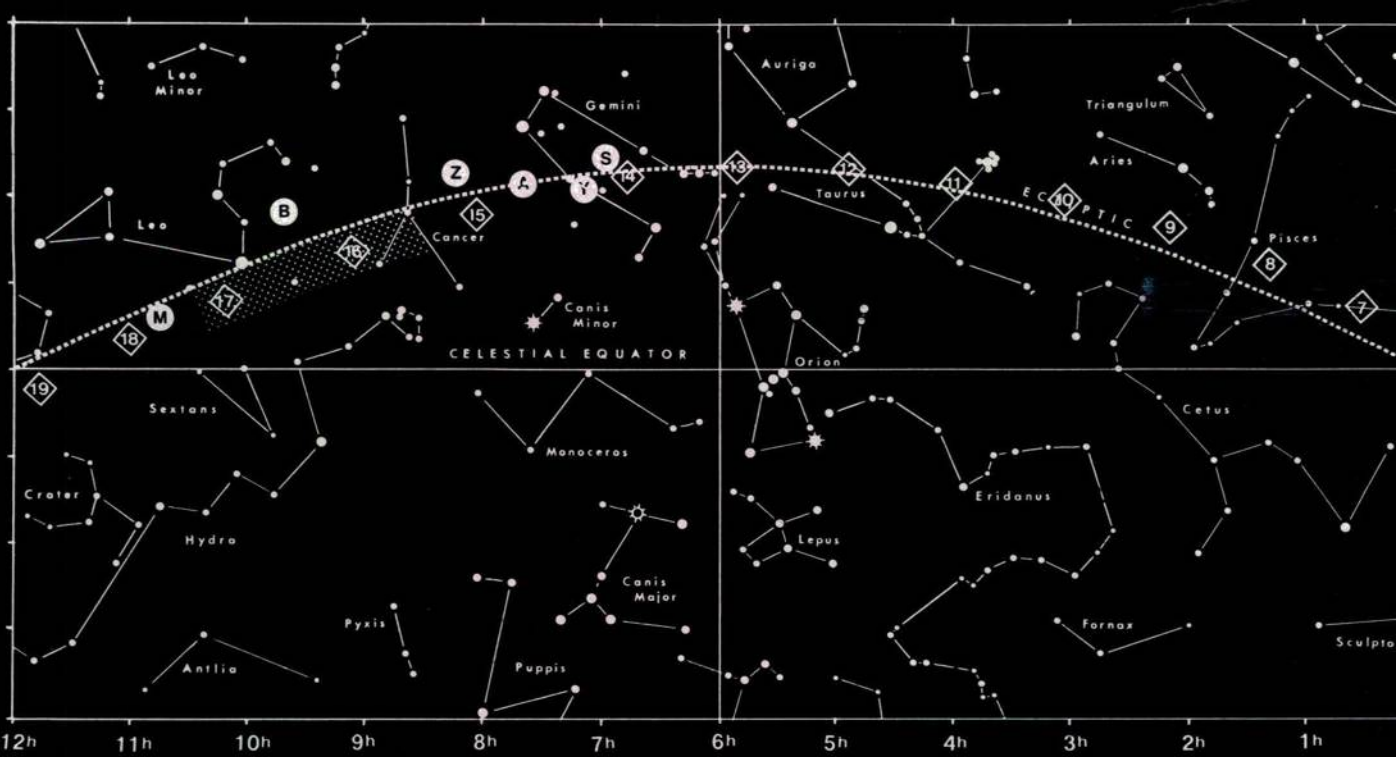


Ⓤ Uranus

Aug.	15
R.A.	13h32m
Dec.	-9°00'
Dia.	3.6"
Mag.	+5.7

Ⓝ Neptune

Aug.	15
R.A.	16h21m
Dec.	-19°53'
Dia.	2.5"
Mag.	+7.7

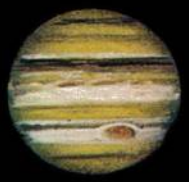


Map by Raymond G. Coutchie

The chart shows the positions of the moon, planets and brightest asteroids for the current month. Letters within the circles correspond to the letters beside each object in the data section above the map. Additional information about each object is given there. **R.A.** = right ascension and **Dec.** = declination, the two coordinates used to locate astronomical objects. The general coordinate system is indicated around the edge of the map. **Mag.** = magnitude, a

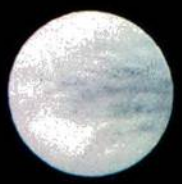
Ⓥ Vesta

Aug.	1	15
R.A.	13h30m	13h51m
Dec.	-3°09'	-6°05'
Mag.	+6.9	+7.0



Ⓙ Jupiter

Aug.	1	15
R.A.	23h15m	23h09m
Dec.	-6°27'	-7°01'
Dia.	47.5"	48.5"
Mag.	-2.4	-2.4



Ⓨ Venus

Aug.	1
R.A.	7h02m
Dec.	+22°26'
Dia.	11.2"
Mag.	-3.3

Ⓩ Venus

Aug.	15
R.A.	8h14m
Dec.	+20°15'
Dia.	10.8"
Mag.	-3.4

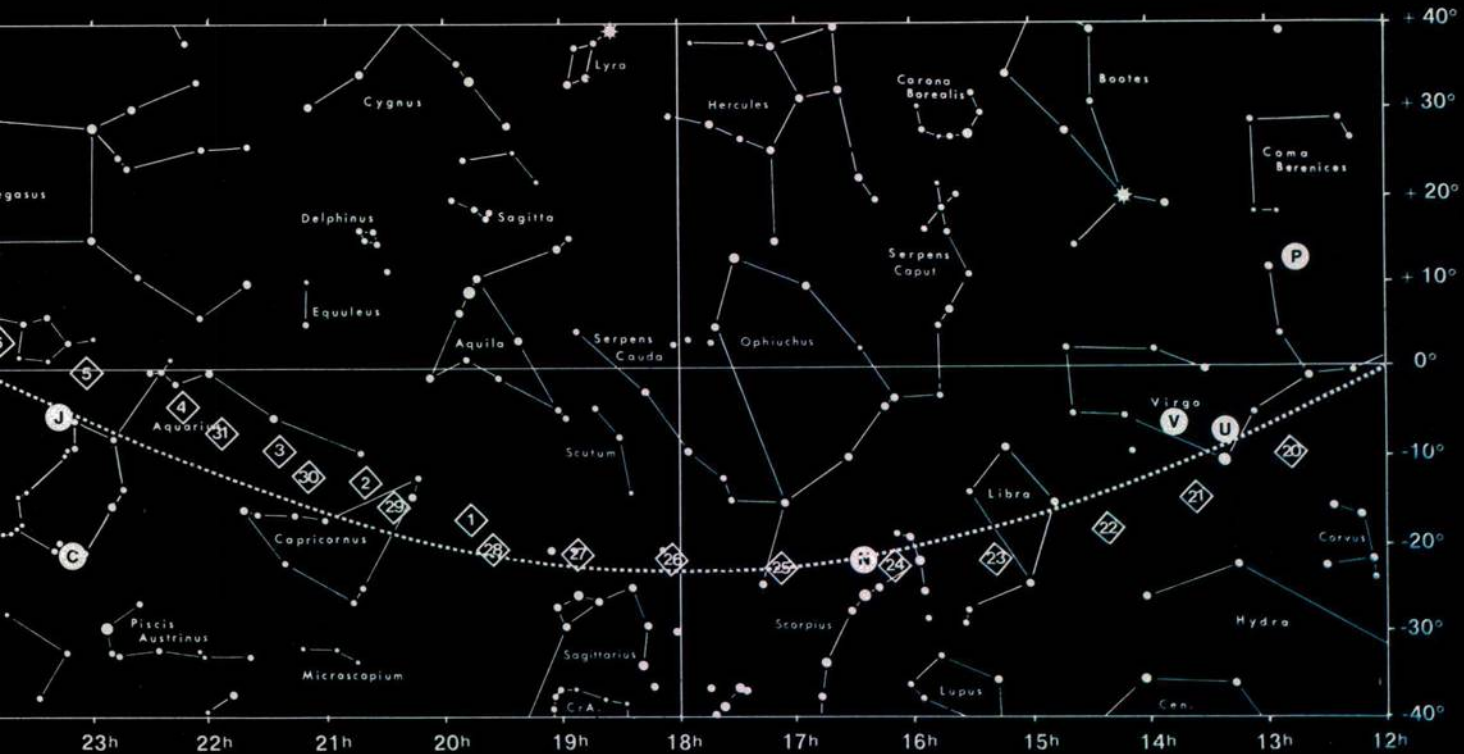
Ⓟ Pluto

Aug.	15
R.A.	12h43m
Dec.	+13°03'
Mag.	+1.4

First Quarter
Aug. 24

Full Moon
Aug. 2

Last Quarter
Aug. 10



measurement of the object's brightness. (The minus magnitudes indicate very bright planets.) **Dia.** = the planet's apparent diameter in seconds of arc. The diamonds with numbers within them indicate the position of the moon for each day of the month; the numbers correspond to the dates. Positions of the planets are for the 15th of the month except for Mercury and Venus which are shown on both the 1st and 15th.

Artwork by Victor Costanzo

the Perseid shower is washed out by the full moon — as in 1973 — but this year conditions are good.

Jupiter

The big planet moves into good position for observing this month since it rises in the southeast an hour or so after sunset. It can't be mistaken; at magnitude -2.4 it far outshines everything else in the evening sky except the moon. Its brightness often draws remarks from nonastronomers like, "What's that bright yellow thing? It looks like a plane but it doesn't move."

A telescope takes Jupiter from the realm of "a bright yellow thing" to a fascinating celestial interplay of planet and moons. The giant world's four moons skate from side to side as you watch from night to night. Our diagram shows their positions for each evening this month. In the next issue of ASTRONOMY a feature on observing and photographing Jupiter will help guide your exploration of the solar system's largest planet.

During August, Earth swings to almost its smallest possible separation from Jupiter as the distance decreases from 386 million miles on the 1st to 370 million miles by the 31st. This decrease causes an increase in the planet's apparent equatorial diameter from 47.5 seconds of arc to 49.5 during the month. Because Jupiter bulges at the equator the polar diameter increases from 44.2 to 46.2 seconds in the same period. For comparison, the entire width of Saturn's rings seldom exceeds 46 seconds from edge to edge.

The shadows of Jupiter's moons are always fun to observe. Are the shadows of Europa and Callisto more difficult that those of Io and Ganymede? Are any or all visible in a 2.4 inch refractor? Jupiter will be with us in the evening sky for the rest of the year, so enjoy it.

Venus

For about 1-1/2 hours before sunrise the brightest planet is dazzling white (magnitude -3.3) in the southeast. It has been there for most of the year so far and will continue to reside in the morning sky, although less and less prominently for another month or so.

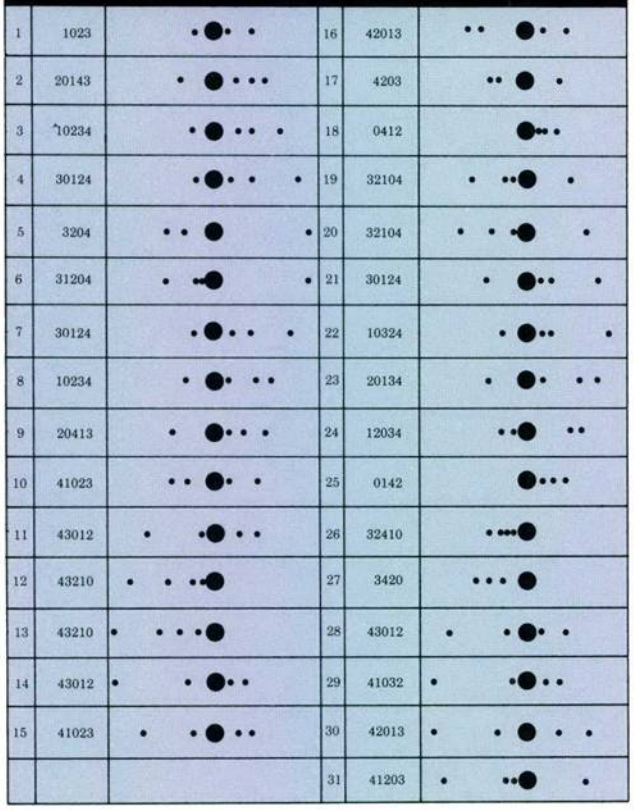
Telescopically Venus is of little interest now because it is well around on the far side of its orbit and is still receding. Its distance increases from 139 to 150 million miles during August while its diameter dwindles from 11.2 to 10.4 seconds of arc. Under fairly high power you may be able

SATELLITE SHADOWS ON JUPITER

Date	Satellite	Transit begins (EDT)	Transit ends (EDT)
Aug. 2	2	12:02 a.m.	2:53 a.m.
5	1	2:39 a.m.	4:55 a.m.
6	1	9:07 p.m.	11:23 p.m.
9	2	2:38 a.m.	5:29 a.m.
9-10	4	11:12 p.m.	3:05 a.m.
11	3	in progress	10:52 p.m.
12	1	4:33 a.m.	6:49 a.m.
13-14	1	11:01 p.m.	1:18 a.m.
18-19	3	11:26 p.m.	2:52 a.m.
21	1	12:55 a.m.	3:12 a.m.
26	3	3:26 a.m.	6:52 a.m.
26	2	9:08 p.m.	11:58 p.m.
26	4	in progress	9:15 p.m.
28	1	2:50 a.m.	5:07 a.m.
29	1	9:19 p.m.	11:36 p.m.

1 = Io, 2 = Europa, 3 = Ganymede, 4 = Callisto

SATELLITES OF JUPITER AUGUST



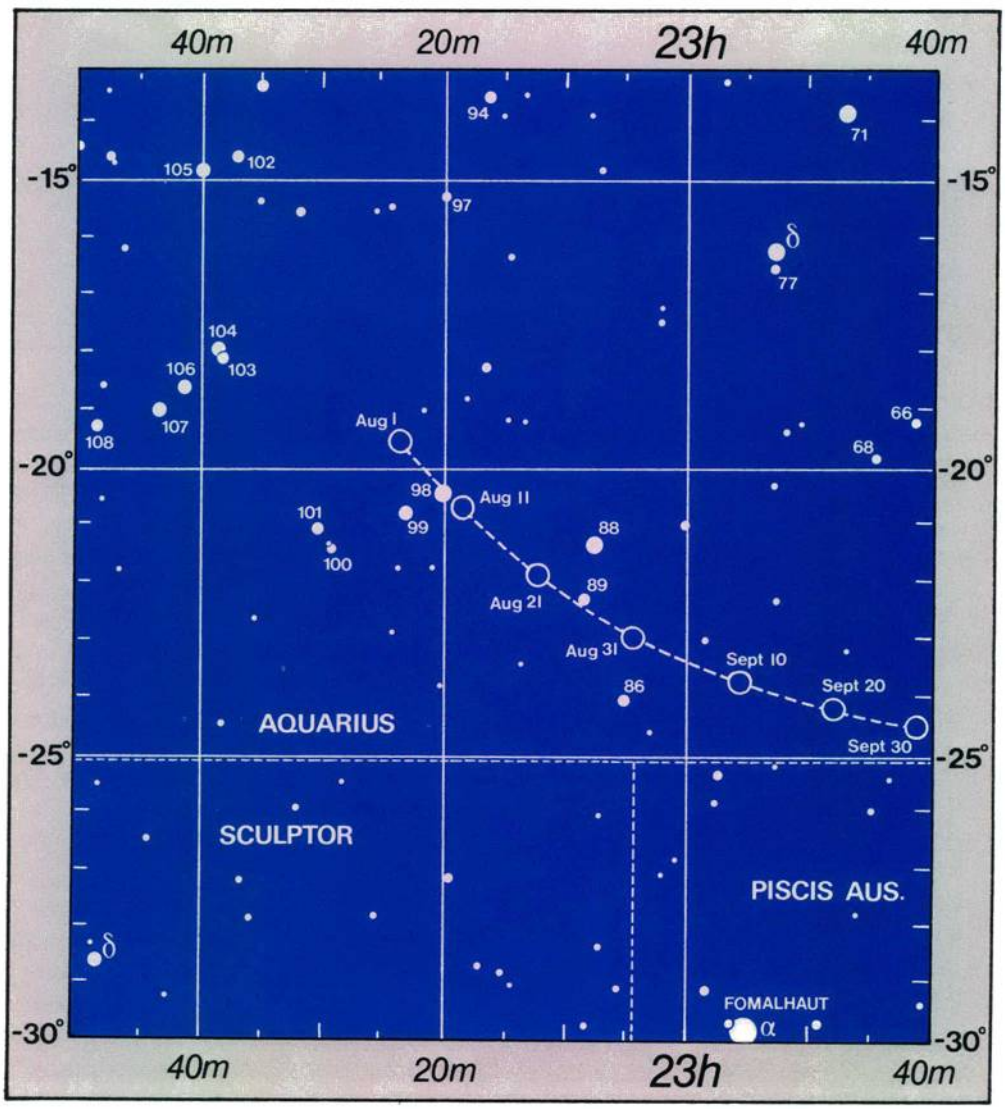
The four major satellites of Jupiter orbit the giant planet in periods ranging from just under 2 days to 17 days. They can be seen to change position from night to night. Sometimes their motions become evident after only a few minutes' observation. Only a small telescope is required to detect all four of the satellites and several can frequently be seen in rigidly held binoculars. This table shows the approximate positions of the moons at about midnight (EDT) on the evenings indicated. First column on the left shows the date. Second column of numbers identifies the moons and their positions relative to Jupiter's disk. (1 = Io; 2 = Europa; 3 = Ganymede; 4 = Callisto, and 0 = Jupiter's disk.) The third column approximates a telescopic view of the satellites' positions. The orientation of the satellites is shown inverted as seen in a standard astronomical telescope.

to distinguish the phase although it is nearly full — 90 percent on the 1st growing to 95 percent by the 31st.

Saturn

Saturn rises in the east about three hours before the sun and is quite bright at magnitude +0.4 in southern Gemini. Through practically any telescope the rings can be distinguished appearing about 38 seconds of arc from edge to edge (80 percent of the present width of Jupiter as seen from Earth). The distance of Saturn during August decreases from 921 to 893 million miles.

Observers with telescopes over six inches aperture may want to try to watch a magnitude 9.0 star (called SAO-79100) be covered by the rings on the morning of the 29th. At 3:25 a.m. EDT the outer edge of the rings will occult (pass in front of) the star. Re-emergence will occur at 5:13 a.m. The star should be easily seen as Saturn slowly moves toward it, however the actual disappearance will be difficult to observe. The event can only be seen from the eastern half of North America.



Map by Victor Costanzo

Ceres, second brightest of the asteroids, will seem to glide through the star fields of Aquarius this summer as it makes a relatively close approach to Earth. The asteroid's position every 10 days is indicated although it's easy to estimate where it will be on any particular night. The circles for Ceres do not represent its magnitude since it will be +7.3 for most of this period — about the same brightness as the faintest stars indicated. For comparison, the star marked 88 in Aquarius is +3.7 while 89 in that same constellation is +4.7. Binoculars should show all the stars on this chart as well as Ceres. See the map on page 26 for general location of Fomalhaut and Delta Aquarii.

Photograph by Wayne Batteiger

Mercury, Saturn and the moon brightened the twilight glow about 50 minutes after sunset on May 23, 1974. Photo, taken near St. Louis, Mo., is a one second exposure on High Speed Ektachrome. Saturn is the bright object above the moon while Mercury just peeks over the trees slightly right of center.

Mars and Mercury

Both of these planets are unobservable this month because of their apparent nearness to the sun. They are in fact on the far sides of their orbits from an Earthbound viewpoint.

Ceres

The largest but second brightest of the asteroids is a 600 mile wide midget planet that orbits the sun between Mars and Jupiter. Ceres never appears brighter than magnitude 6.5 so it is always a binocular object at best. Because of Ceres' elliptical orbit it can be as close as 144 million miles from Earth or as distant as 372 million miles when it is at the far side of its orbit.

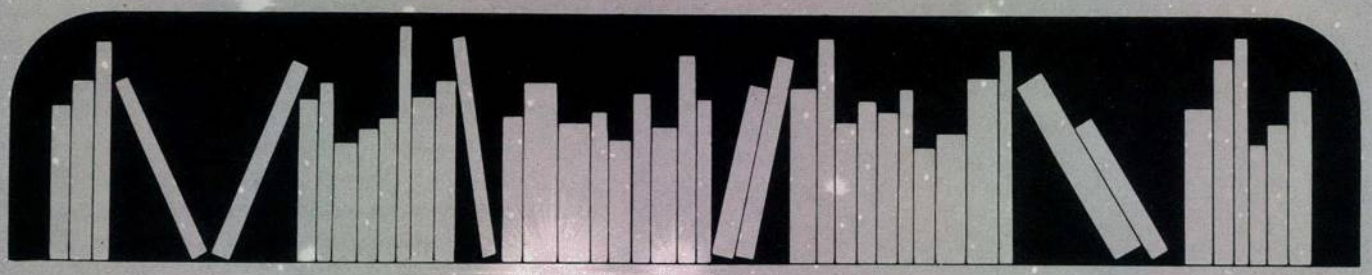
This year we don't get favored with a really close approach since the minimum distance (Aug. 31) will be 186 million miles. The differences in close approach separation are due largely to Ceres' elliptical orbit.

For observers this particular chance to see Ceres has its good and bad points. First the good news: It's summer and a perfect time for asteroid hunting; the next opportunity for Ceres is Dec. 1975. The bad news is the southern location of Ceres as you will see when you start using the chart. Look for first magnitude Fomalhaut low in the south around 1:00 a.m. early in the month and at about 11:00 p.m. by early September — and zero in on Ceres from there.

Because Ceres is not as close as it sometimes gets, its magnitude is well below the 6.5 optimum. On Aug. 1 it is 7.4 and by the 31st will have brightened by a barely noticeable amount to 7.3. By the end of September it will be 7.4 and fades rapidly thereafter.

To find Ceres, try to locate all the stars on the chart with binoculars. The asteroid will be an extra "star" at the position marked for the date you are observing. To make it easier for yourself, rest your binoculars (preferably 7 x 50 or 10 x 50 size) on a fencepost — or better still, get a binocular attachment for your camera tripod.

Since Ceres looks just like a star you might ask why bother searching at all. Ceres, like all planets, moves among the stars as it pursues its orbit. The motion is easily detected as it seems to wind its way among the more distant stars. A second reason is simply the satisfaction of finding and observing a tiny world — the king of the midgets.



The Cosmic Connection — An Extraterrestrial Perspective

by CARL SAGAN
288 pages, hardcover, $7.95
Doubleday & Company, Inc. (1973)

"After centuries of muddy surmise, unfettered speculation, stodgy conservatism, and unimaginative disinterest, the subject of extraterrestrial life has finally come of age."

So says Carl Sagan in his introduction to what has to be a milestone in popular science writing. This book is an "absolute must" for anyone interested in the subject of life on other worlds, and it is intriguing casual reading for others who may have had fleeting encounters with the mind expanding concept of life beyond our own planet.

Books on flying saucers, on visits to Earth by beings from other planets, or on the possibility of life "out there" will come and go; there are dozens printed every year. However this book will last — it's special. It provides, through Sagan's keen insight and awareness, a unique view of the interrelationship of astronomy, biology, philosophy and human behavior. We get, as the title implies, an extraterrestrial perspective in clean concise language filled with information — without being dry. On the contrary, the text is brilliantly written and mind expanding in scope.

Several chapters of the book have been printed in previous issues of this magazine and almost all the chapters stand alone as neat, descriptive packages. Some chapter titles are: "On Teaching the First Grade", "The Venus Detective Story", "Terraforming the Planets", "Has the Earth Been Visited?", and "A Passage to Elsewhen".

There are 39 chapters divided into three sections. Part one conveys a sense of cosmic perspective for Earthlings who, in Sagan's words, are "living out our lives on a tiny hunk of rock and metal circling one of 250 billion stars that make up our galaxy in a universe of billions of galaxies". (In an understatement he says, "The deflation of some of our more common conceits is one of the practical applications of astronomy.")

The second part of the book concerns the solar system — mostly Earth, Mars and Venus. And part three is devoted to the possibility of communicating with extraterrestrial intelligence on planets of other stars.

In the six months since it has been published, 30,000 copies of **The Cosmic Connection** have been sold in hardcover. Although no plans are afoot to put the book in paperback, it is already a best seller — and in terms of astronomy books (nontextbooks), it is a "superbest" seller.

In every chapter, indeed in almost every sentence, your mind is cast out among the stars to probe and question in a way that you probably never have before. You'll voyage to the farthest corners of the universe and zip back to examine microscopic life on Earth to see if there is a relationship between how life started on our planet and how it might have begun elsewhere. Don't worry about abstruse jargon; this book is totally comprehensible to anyone who is interested enough to be reading this magazine. From cover to cover, **The Cosmic Connection** is a superb cross section of that most fascinating of topics: extraterrestrial life.

Starflight and Other Improbabilities

by BEN BOVA
126 pages, hardcover, $4.75
Westminster Press (1973)

The gulf between science fiction and science fact has been narrowing lately. Today's science fact includes manned voyages to the moon and the robot Pioneer 10 slowly threading its way to the stars. Yet only two decades ago such journeys were considered speculation, and few scientists would touch such topics.

In a modern parallel, Ben Bova envisions a television talk show where the moderator is a science fiction writer, and his guests are several scientists representing various fields. They get into a heated discussion about flight to the stars. "It's impossible to get to the stars," says the physicist. "What about hyperspace drive?" asks the science fiction writer.

The questions and sparring are delightful reading and Bova — author of both science and science fiction — handles it beautifully. But this imaginary panel show is only the first chapter. There are others on distances in space, UFO's and extraterrestrial life, pulsars, black holes and supernovae, and more on starflight. If you enjoyed Bova's article in this issue you should get this book. Our only complaint is its size — it's too small. We want more.

Interstellar Communication: A Scientific Perspective

edited by CYRIL PONNAMPERUMA and A.G.W. CAMERON
226 pages, paperback, $5.95
Houghton-Mifflin (1974)

The two books reviewed above offer excellent introductions to the fascinating question of intelligent life beyond Earth. This book is a logical next step for those who want greater depth of treatment.

Four years ago NASA sponsored a series of lectures in San Francisco. The 10 speakers included some of the top thinkers in various fields of science related to the extraterrestrial intelligence question. These talks were edited, updated and collected to form this volume.

As always, Carl Sagan's contribution is excellent, as is the discussion of the likelihood of other planetary systems by A.G.W. Cameron. Some of the other chapters may be tough going for the general reader, but all in all this book presents a fine detailed overview of a subject that has unfortunately spawned a lot of junk.

One welcome and especially valuable feature is the huge bibliography that lists over 500 articles and books dealing with extraterrestrial intelligence and allied topics.

PUBLISHER'S MEMO

Well, ASTRONOMY's Circulation Contest is over, and it certainly was an interesting as well as an educational experience for us. The three top winners who submitted the most entries and have won lifetime subscriptions to ASTRONOMY are: 1st place, $150 — A.R. Lieberman, Lutherville, Md.; 2nd place, $100 — Roger D. Paterson, M.D., Manistee, Mich.; 3rd place, $50 — Victor A. Kandelin, Chichester, N.H.

As you know, ASTRONOMY has been trying to bring its circulation to around 40,000 subscribers so we may add 16 more pages to the magazine on a monthly basis. While our Circulation Contest resulted in many new subscribers, it did not produce the results we had hoped for. Therefore, in an attempt to entice new readers to our magazine, we are conducting a direct mail campaign this month to more than a half million people across the country with a special premium offer if they give ASTRONOMY a try. This special premium offer is a full color poster (measuring 22 x 34 inches) of the artwork used to illustrate the lead article this month by Ben Bova. If new subscribers send in payment with their subscription, they will receive this beautiful poster absolutely free.

The reason I am telling you this beforehand is because many of our subscribers will probably receive one of our direct mail brochures sometime this month. While we would certainly like to give our readers an opportunity to receive this free poster, it simply is not possible. Depending on the success of the direct mail campaign, we may offer this poster for sale to readers before Christmas at $3.50.

We trust you understand our position and hope it in no way inconveniences you. After all, in the final analysis, you, our current subscribers, will come out ahead — especially if we can offer magazines like last month's issue.

Sincerely,

Stephen A. Walther

Stephen A. Walther
Publisher

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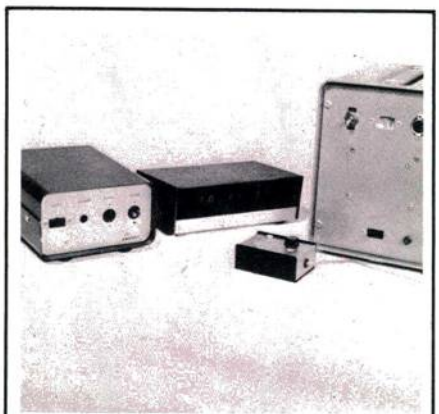

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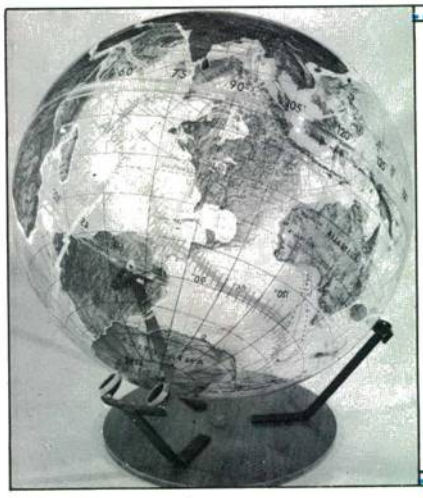

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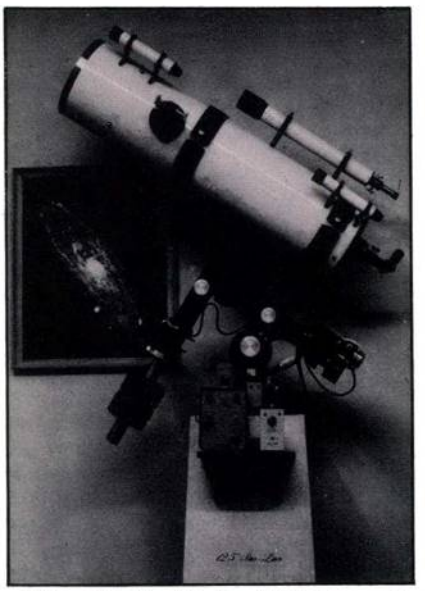

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The Oct. 1973 issue of ASTRONOMY is completely sold out; certain other issues are in short supply. While they last, back issues are available for the cover price of $1.50 each (price includes postage). When ordering, state which issues you want (first issue was Aug. 1973) and include payment with request. Back issue orders cannot be billed.

WANTED — Color and black and white photos of sky objects for publication in ASTRONOMY. Payment upon publication is $10.00 for color and $7.50 for B & W plus credit line. Higher payment for outstanding color photos. Send B & W prints or duplicate color transparencies. Do not send original negatives; we will request originals if needed. Send to The Editors, ASTRONOMY, 757 N. Broadway, Suite 204, Milwaukee, WI 53202.

WANTED — "American Ephemeris and Nautical Almanac" (1970). Must be in reasonable condition. Will pay up to $4.00. Write Scott Siglin, 1005 Prospect Blvd., Waterloo, IA 50701.

WANTED — Binocular (20 x 60 or 20 x 70) tripod or monopod. Write Donald B. Miller, Majestic Towers, Apt. 1227-B, 1255 Pasadena Ave. S., St. Petersburg, FL 33707.

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ASTRO-NEWS

Latest News From the World of Astronomy

Baffling Radiation Bursts Detected

Optical astronomers, using telescopes like the 200 inch giant on Mt. Palomar, were perplexed with the quasars they discovered 11 years ago. Today these strange objects still defy complete explanation as recent items in this department have chronicled. Radio astronomers, too, have their bag full of weird and violent enigmas in deep space. It seems as soon as one puzzle is solved another pops up to replace it.

Now an exotic new kind of "telescope", set up in a mine a mile beneath the Black Hills of South Dakota, is joining the act by recording strange bursts of antineutrino radiation.

The new instruments — really sensor-laden water tanks — join a similar neutrino detector that has been in operation at the same site for several years.

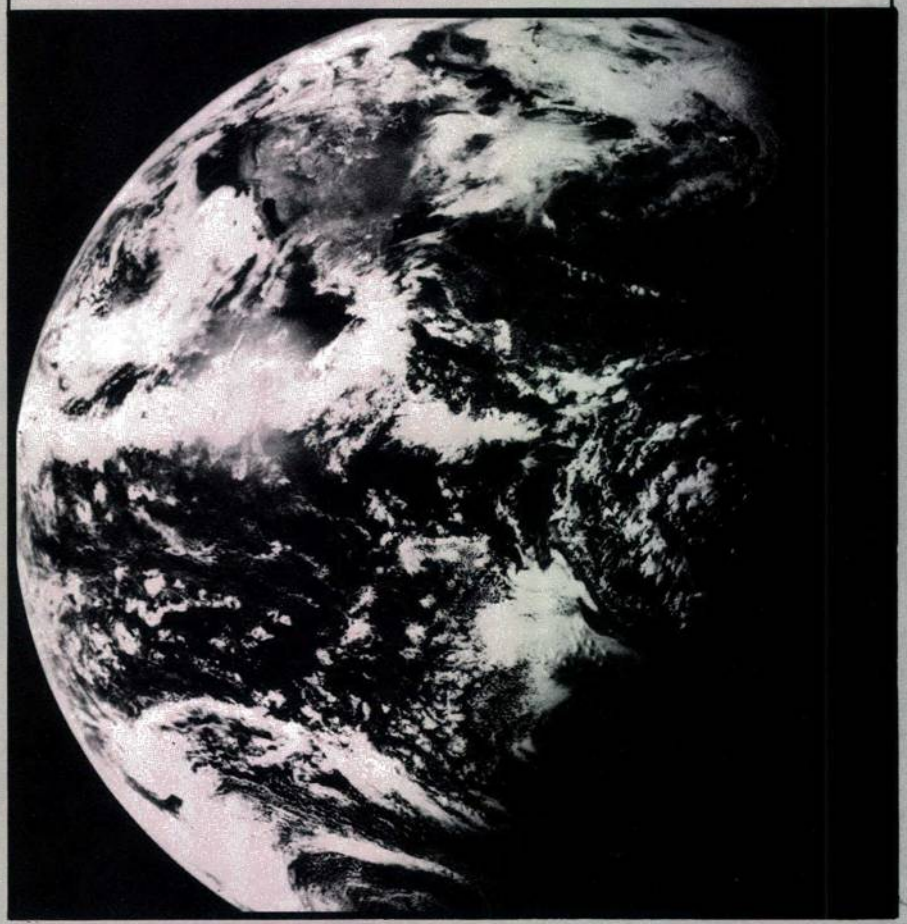
Most neutrinos and antineutrinos zip through Earth without the slightest problem. Only when they encounter a proton head-on do they give a detectable emission. Both neutrinos and antineutrinos are considered "snobs" since only 1 in 100 billion that pass through Earth interacts with other atomic particles. The new detectors are, for the first time, capable of "seeing" these rare interactions.

While the neutrino detector has caused some problems for solar astronomers (page 11, July 1974 issue), the new antineutrino device has astrophysicists scratching their heads. On Jan. 4, 1974 it measured four monstrous bursts only a thousandth of a second apart, the last of which drove the recorder right off the scale. So far this is the only major event noted but it followed a pattern that fits into a theory proposed by Stirling A. Colgate of the New Mexico Institute of Mining and Technology.

Colgate and others predict that a white dwarf star can, under certain

Radiation continued on pg. 52

Synchronous Shutterbug



NASA Photograph

From a vantage point 21,272 miles above the equator, NASA's first Synchronous Meteorological Satellite (SMS-1) scans the western hemisphere daily. The satellite orbits the globe in exact pace with our planets' rotation and is capable of both day and night photography. Features in photo not obscured by clouds are the western United States and northern Mexico (upper left) and western South America (center). Photo resolution is ½ mile — far exceeding previous global resolution from a weather satellite.

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Cosmic Boulder Skims Over Rockies

A chunk of interplanetary rock, perhaps as large as an apartment building, skimmed over the Rocky Mountains two years ago. This conclusion comes from intensive study of hundreds of reports made by observers who watched in awe as a dazzling object raced over Utah, Idaho, Montana and Alberta, Canada on Aug. 10, 1972. Many reports described the bolide (bright meteor) as magnitude -16 or -17, or more than 10 times brighter than the full moon. These reports, combined with valuable data from a near infrared detector on an Earth satellite yield an interesting scenario.

At about 2:30 p.m. MDT an object ranging from 20 to 200 feet in diameter and weighing between 1,000 and 1,000,000 tons (the figures depend on whose estimates you accept and whether the object was iron or rock) swept to within 36 miles of Earth. The point of closest approach was apparently over Idaho near the town of Birch Creek.

This rare object was large enough to have caused extensive damage equivalent to a small atomic device had it actually collided with land. It was an extremely close shave!

Orbital calculations show the big boulder is orbiting the sun between Earth and Mars with its near point skimming our planet's orbit. The recent near miss has changed the object's orbit so that future encounters are less likely.

Funds Cut for Large Space Telescope

In a nearly unanimous vote the House of Representatives accepted a recommendation of its Appropriations Committee to cut all funding for the Large Space Telescope (LST), at least for 1975. NASA had requested $6.2 million for next year's design studies for the 120 inch telescope which was expected to be put into orbit in about 10 years.

The committee had balked at the $400 million total cost of the project and suggested NASA consider a less costly alternative. The largest telescope orbited to date is a 38 inch instrument.

The LST was expected to have at least 10 times the resolution of any Earth based telescope and many astronomers believed it would be able to crack some of the deepest cosmic puzzles.

In view of the LST's long range potential, NASA is urging the Senate to restore the funds — an approach that may result in a compromise.

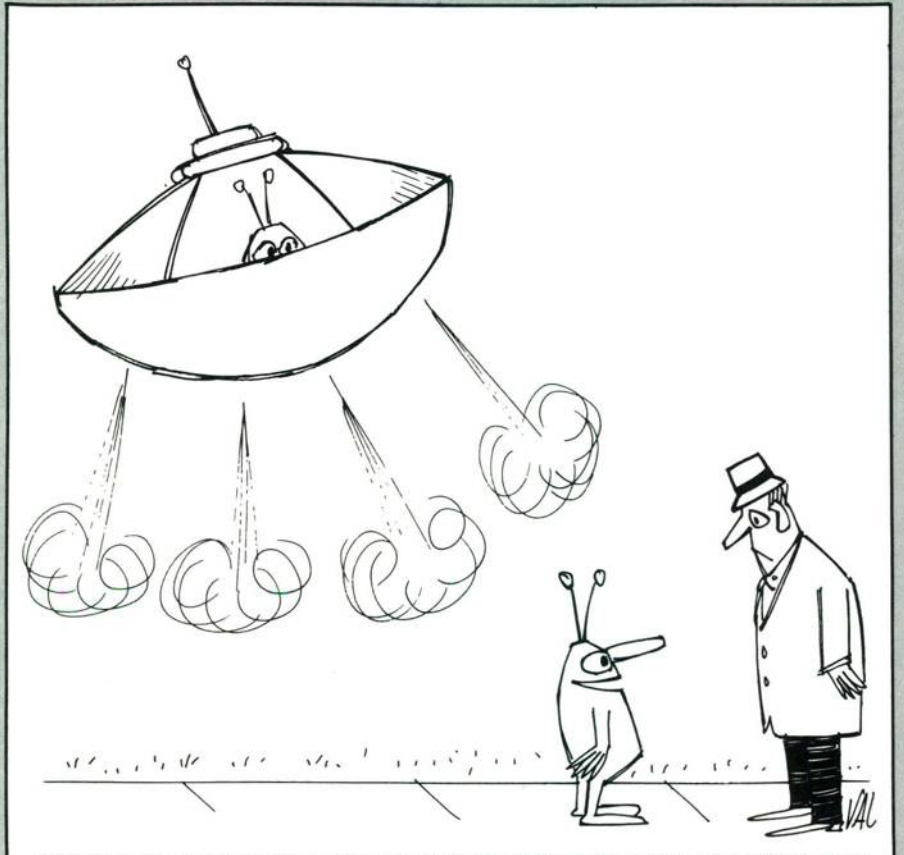
Radiation

continued from pg. 51

circumstances, collapse to a neutron star or black hole. During the collapse the star "shudders" and, for an instant, bounces back a slight amount before proceeding to collapse. These shudders are thought to be accompanied by vast ejections of antineutrinos in bursts a thousandth of a second apart — precisely what was detected by the new instruments.

This theory also accounts for the fact that a supernova was not observed at or near the time of the antineutrino detection. Otherwise a supernova ultimately collapsing to form a neutron star or black hole would have been the most logical explanation. Colgate points out that a white dwarf becoming a neutron star or black hole would likely produce little light and hence go undetected except for the antineutrino bursts.

Similar eruptions of gamma rays have also been detected and may be explained in a similar manner (see page 31, July 1974). However, the matter is by no means solved and many astrophysicists consider these monstrous and rapid bursts of energy quite baffling. More detectors are under construction to work on this newest cosmic enigma.



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More Clues to Origins of Life

The building blocks of life — the so-called prebiotic molecules — have been falling from space continuously since the origin of Earth. This is the conclusion of University of Washington astronomer Paul W. Hodge who reported on recent Skylab experiment results at a gathering of astronomers in Winnipeg, Canada.

The Skylab experiment involved a piece of metal that was exposed outside the craft for several minutes. Micrometeorites that struck the metal left tiny craters and part of themselves behind. (A photo of such an event was included in the Skylab article last month.)

Hodge reported the first successful analysis of uncontaminated meteoric material from this experiment. The material proved to be very much like carbonaceous chondrites (meteoric material that has reached Earth's surface, and when analyzed, is found to contain organic-like matter). Such material is considered prebiotic; that is, the type of stuff living things are made of.

The fascinating conclusion Hodge makes from this is that "the building blocks of life have been falling here, and elsewhere, for billions of years thus providing another source for life besides the 'primordial soup' hypothesis now considered the likely birthplace of Earth life."

Since most of the tiny meteoric material between the planets was created with the rest of the solar system five billion years ago, it seems logical to assume that all planetary systems similar to the sun's should have prebiotic material raining from the skies. This, says Hodge, adds another possibility for life's origin here and increases its probability elsewhere.

Astronomy for Campers

How would you like to spend your summer traveling among government parks with a carload of telescopes that you use to demonstrate celestial showpieces to campers and get paid for it? Several amateur and one professional astronomer in the United States and Canada are now being subsidized by various government agencies to do just that.

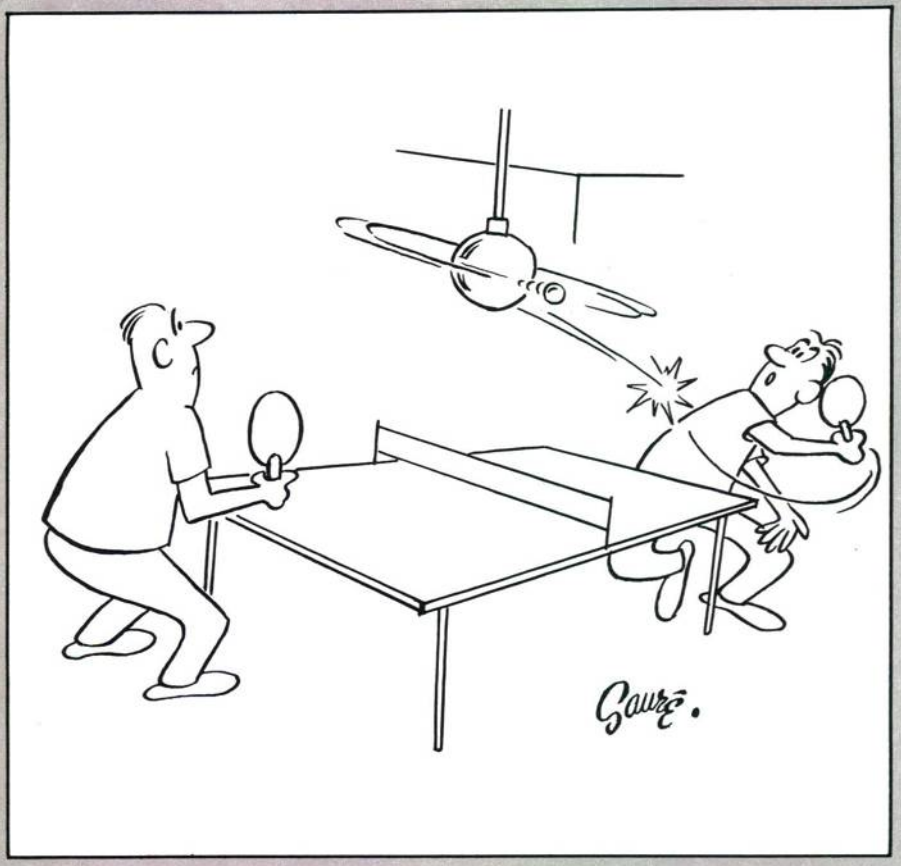
In all cases the individuals conducting the portable astronomy classes simply approached the appropriate government department with a proposal that was subsequently funded. The programs are basically like this:

The astronomy instructors, numbering from one to four, spend a few days at each park in the system from late June to early September. They are generally experienced campers and must be advanced amateur astronomers. A moderately large telescope, several binoculars, a slide projector and screen comprise the demonstration equipment. A particularly useful and inexpensive aid is a powerful flashlight that has a rolled tube parallel to the beam. (It's easy to make and ends up looking like a stovepipe on the front end of the flashlight.) For star identification the beam is simply aimed at the desired spot; it forms a beautiful wand that is vastly superior to pointing your finger and saying, "Now over here we see the constellation...."

The parks' authorities usually publicize the presence of the astronomy team which conducts solar observing during the day and viewing of the moon, planets and star clusters at night. A slide show and popular talk supplements the observing and substitutes on cloudy nights.

Because excellent skies are available at many campsites, the program is more effective than urban or suburban public observing sessions. Secondly, the park patrons are generally more receptive to the astronomy exposure because of the brilliant skies and vacation atmosphere that pervades a campsite.

Some enterprising high school and college students are already spending their summers being paid to camp out and teach astronomy. Fun? You bet it is.



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AUGUST

Stars in each constellation are indicated, in order of brightness, with the Greek Alphabet.

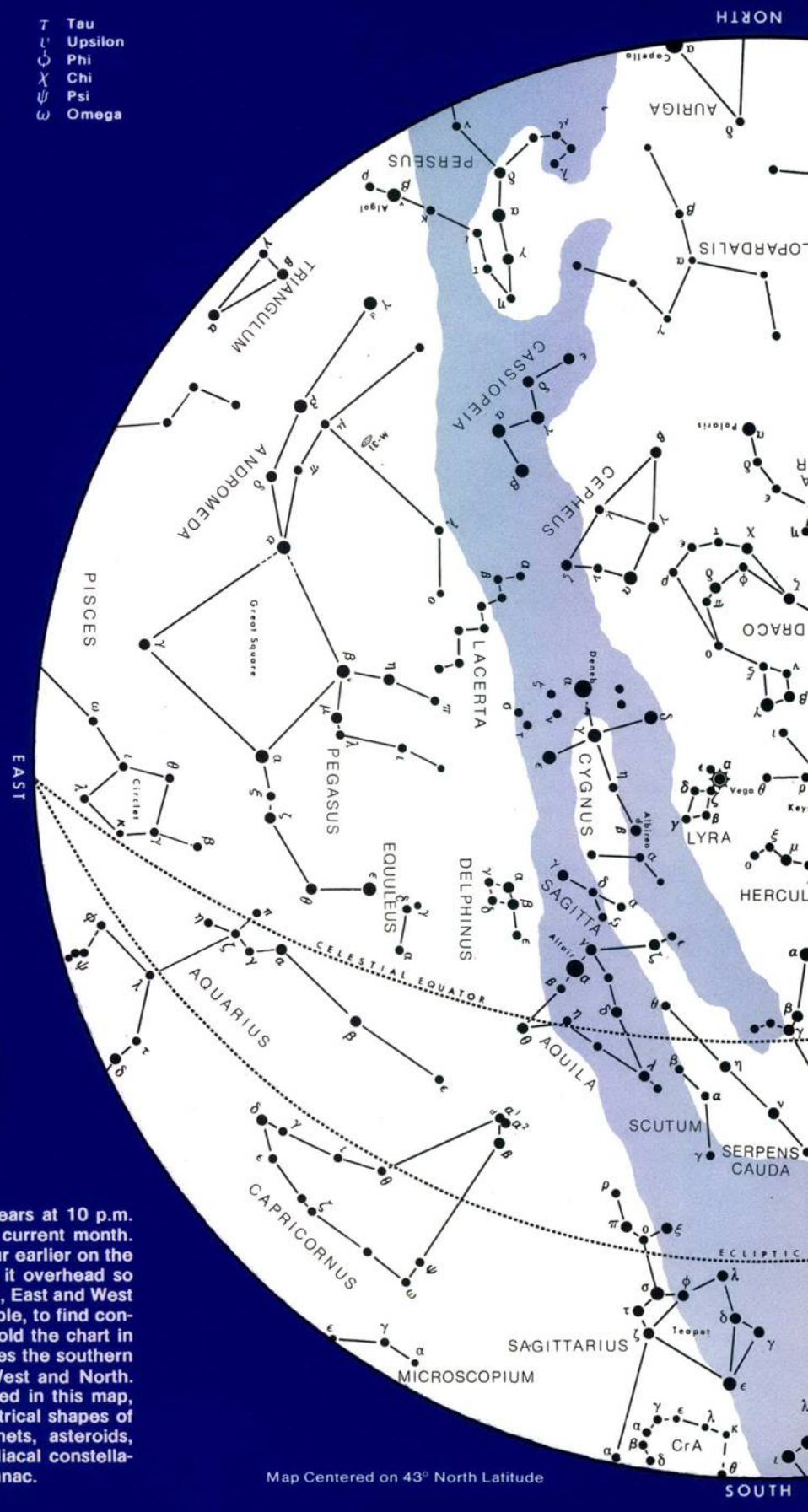
α	Alpha	η	Eta	ν	Nu	τ	Tau
β	Beta	θ	Theta	ξ	Xi	υ	Upsilon
γ	Gamma	ι	Iota	ο	Omicron	φ	Phi
δ	Delta	κ	Kappa	π	Pi	χ	Chi
ε	Epsilon	λ	Lambda	ρ	Rho	ψ	Psi
ζ	Zeta	μ	Mu	σ	Sigma	ω	Omega

MAGNITUDES

- Zero
- First
- Second
- Third
- Fourth
- Fifth

OBJECTS

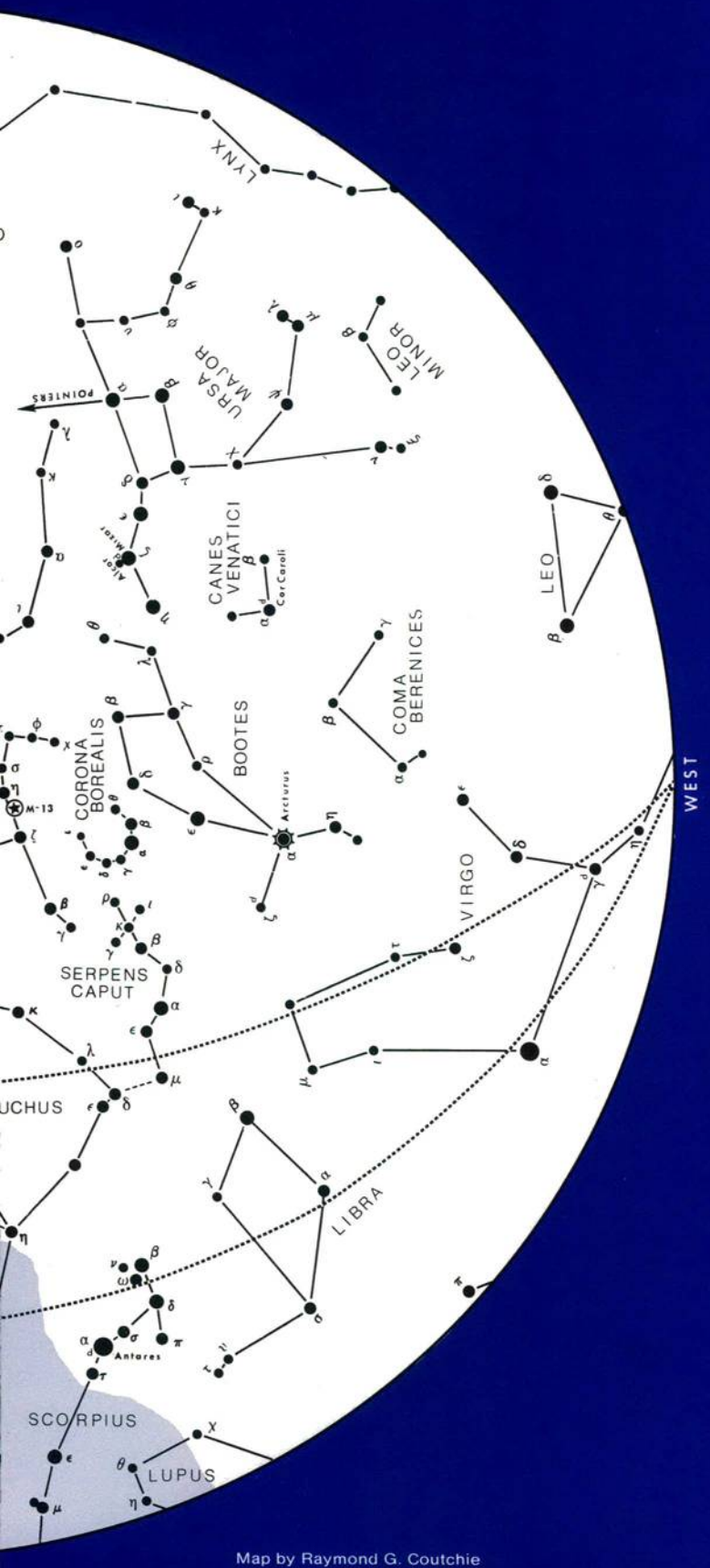
- Open Clusters
- Globular Clusters
- Diffuse Nebulae
- Galaxies
- Double Stars
- Variable Stars



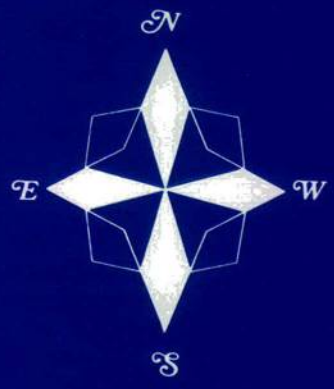
Map Centered on 43° North Latitude

Star Dome approximates the sky as it appears at 10 p.m. Local Daylight Time on the first day of the current month. The same constellations are visible one hour earlier on the 15th. To use this constellation finder, hold it overhead so the compass points line up with North, South, East and West in your backyard or viewing area. For example, to find constellations in the southern part of the sky hold the chart in front of you so the South compass point faces the southern horizon. Repeat this procedure for East, West and North. Since only the brighter stars are represented in this map, you should be able to trace out the geometrical shapes of the constellations with ease. To find planets, asteroids, etc., visible among the current month's zodiacal constellations, refer to the planet finder in Sky Almanac.

STAR DOME



Map by Raymond G. Coutchie



Have you always wanted to be able to find the stars and constellations and planets — but when you're actually confronted with a sky full of stars that seem to be randomly scattered across the vault of the sky, you cringe? You say, "I'll never find my way. I can't tell a Saturn from a Vega from a Pegasus."

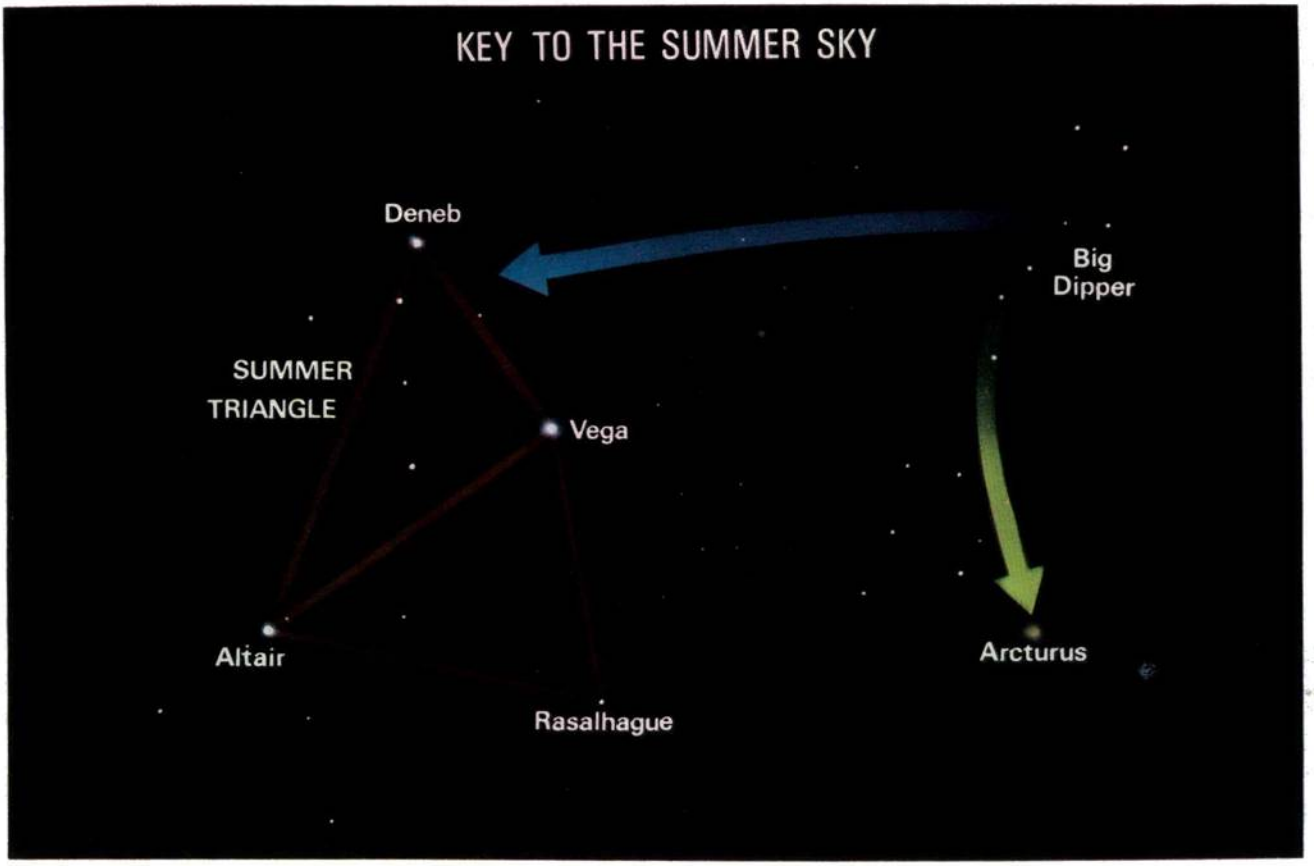
And then you try a star map like the one on this page. You hold it up in front of you and still you can't seem to identify the stars that are so plainly printed on the map but elude you when you're faced with the actual sky. If you're one of these people, read on.

The way to start finding your way around the sky is *not* to hold this map up to the sky and start looking for the things on it. You're really putting the cart before the horse. The way to go about finding your way among the stars is to identify a couple of the bright ones first by the method that we're going to describe, and *then* turn to the map to fill in the details. The guide map on the following page has all you need to get going. Using it, do the following:

Step outside on a clear evening this month. (Even if the moon is in the sky or if you're in a forest of streetlights, you still should be able to accomplish some star identifications.) Face northwest, look high in the sky, and the shape of the Big Dipper's stars should be unmistakable. The Big Dipper's stars are not the brightest in the sky, but they are all approximately second magnitude — that is, not quite as bright as the brightest stars, but brighter than most of them. The key is the distinctive shape of the dipper.

With this single identification, you have opened yourself to discovering the basic elements of the summer sky.

The curve of the Big Dipper's handle forms a natural pointer to the brilliant orange star Arcturus (arc-TOUR-us). Simply extend this curve down



in an arc toward the southwest and it will take you to Arcturus. Arcturus is quite unmistakable, being the only star of great brilliance in its segment of the sky.

The next step is to return to the Big Dipper. This time select the two stars in the bowl that are nearest the handle. Draw a line from the one at the bottom of the bowl up through the one that joins the bowl to the handle, and extend it a good distance across the sky until you come to the vicinity of three bright stars called the Summer Triangle. The triangle is a modern abstraction of old groupings. It consists of the first magnitude stars Deneb, Altair and Vega — each of them the brightest star in its respective constellation of Cygnus, Aquila and Lyra. (You need not be concerned for the moment with the individual constellations.) These three stars form a large and obvious triangle that dominates the overhead part of the sky for the whole summer and early fall.

The brightest of the three is Vega — a brilliant white star with perhaps a touch of blue in it; the next brightest is Altair (al-TARE), also a white star perhaps with yellowish tinges; and finally Deneb (DEN-neb), also a bluish white star like Vega — but fainter than both Vega and Altair. The Summer Triangle is a basic guide to most of the summer and fall sky.

On a line between Vega and Arcturus are two fainter constellations, Hercules and Corona Borealis, which can be identified in detail on the main map. Another constellation with faint stars that covers even a larger area than Hercules is Ophiuchus. Its brightest member, Rasalhague (rass-al-hay-gwee), is located about equidistant from Vega and Altair, and forms a triangle with those two stars. Since Rasalhague is fainter than the stars of the Summer Triangle, this secondary triangle is less obvious — but nevertheless is a perfect way to guide yourself into the dim constellation Ophiuchus (which is explored in detail in this month's Constellation Close-Up). Ophiuchus essentially includes all the stars between Rasalhague and Antares (an-TAR-ease) near the southern horizon. On either side are the two ends of a snake (the constellation Serpens) that Ophiuchus is holding.

According to Greek legend, Ophiuchus was a doctor who killed an intruding snake — the one he is apparently holding in the sky. But the serpent was brought back to life by its mate who stuffed a magic herb into its mouth. Ophiuchus, being an inquiring scientist, searched for the secret of the herb and found it. He was soon able to cure any patient that was brought to him.

This development ruined business for Pluto, the god who ferried dead souls across the river Styx. Pluto, not wanting to become an unemployed guardian of the underworld, stormed up to Jupiter, the king of the gods, and insisted that Ophiuchus be stopped from conducting this super medical practice. So Jupiter placed Ophiuchus among the stars where his fame could be remembered for all time, but his disruption of the normal life and death cycle of humanity would be discontinued.

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CONSTELLATION CLOSE-UP

OPHIUCHUS

by
Thomas C. Bretl

"In Ophiuchus", wrote the late James Sayre Pickering, "you may feel, even with your eyes alone, a sense of something going on. If your seeing is unimpeded... you will receive the impression of vast and awesome activity. Something is there — just beyond your perception — there is no doubt of it."

How true! Hidden within this large, sprawling summer constellation are star fields, clusters, and nebulae galore; yet, even with the aid of a small telescope, most of these objects remain just "beyond our perception". There is an elusive, remote quality about them. They draw our attention — tantalize us — but never completely reveal their true nature.

The Milky Way is not brilliant in Ophiuchus, but its subtle faint fringes are dotted with dark nebular islands of obscuring dust and gas. Sweep across the southern portion of the constellation with a low power eyepiece, and you will surely notice the many abrupt changes from dense star fields to nearly starless ones. The full beauty of the area can only be recorded photographically, and specific dark formations such as Barnard's "S" shaped nebula are almost impossible to detect visually; nevertheless, there is an alluring mystery to this part of the sky that even observers with binoculars will quickly discover. There is, indeed, "something going on"!

Globular clusters head the list of telescopic attractions this month, as more than 20 of these remarkable objects can be found in Ophiuchus with an eight inch telescope. A wide variety of sizes, magnitudes, and stellar concentrations is represented, and several of the larger clusters are quite easily resolved into individual stars. Even these brilliant globulars, however, are in a sense "reluctant" to reveal themselves because Ophiuchus is sadly lacking in prominent stars to serve as landmarks. Many of its clusters are truly "in the middle of nowhere", and just locating them may seem a considerable task.

To find M-10 and M-12, for example, you must first get your eyes well adapted to the dark in order to search for 30 Ophiuchi. This "lonely" fifth magnitude star lies near the middle of the constellation, about 1/3 of the way from Zeta to Beta. Once you find it, it is simple to locate M-10 just one degree to the west, and M-12 only three degrees farther northwest. M-10 and M-12 are of similar size and magnitude, and both are at least partly resolvable in a six inch telescope — although you will probably notice some differences in their appearances. Although M-12 has been described as less concentrated of the two, its many bright and widely scattered stars surround a rather compact and hazy nucleus. M-10, on the other hand, is much more uniform in appearance and is probably the easier to resolve in its entirety.

In striking contrast to both of these clusters, however, is a third globular, M-14. Easy to find just three degrees northwest of 99 Ophiuchi, this cluster is smaller and consists of much fainter stars than either M-10 or M-12. Even a 12 inch telescope shows only a pale, starless cloud. Accurately described as faint and ghostly, it is that "ghostly look" which actually gives M-14 its subtle appeal. Once again we get the impression of something just beyond our grasp.

The area surrounding Xi and Theta Ophiuchi in the southern part of the constellation is as rich in globulars as any other area of the sky. Eight clusters as bright as 10th magnitude can be found here, and all lie within several degrees of their nearest neighbor. The two most conspicuous of these, M-9 and M-19, show signs of resolution in moderate sized telescopes, while the others appear only

as softly glowing, fuzzy spots. Exploring this region requires the same patience, and offers the same rewards, as does "galaxy hunting" in Virgo and Coma Berenices. Just locating and identifying the many objects here is an exciting project in itself.

The Theta Ophiuchi region is also the area where dark peninsulas of dust and gas jut out into the main stream of the summer Milky Way. Barnard's "S" shaped nebula, for example, is located just one degree northwest of 44 Ophiuchi (a fourth magnitude star very close to Theta). As noted earlier, however, these celestial "negative spaces" are extremely difficult to detect visually. Only the cumulative eye of the camera is really able to reveal distinct boundaries between star-rich and star-poor regions. Nevertheless, if you are determined to search for Barnard's nebula despite the inherent frustration, the "S" stretches for about 1/2 degree and is oriented in a northwest-southeast direction.

Several colorful double stars can be found in Ophiuchus, and their moderate separations make them ideal targets for small telescopes. In the rich globular cluster region, for example, both Omicron (39) and 36 Ophiuchi are beautiful, easily resolved pairs. Because of its "setting", however, perhaps the most interesting double in Ophiuchus is Rho, located in the extreme southwestern corner of the constellation only a few degrees from Antares (Alpha Scorpii). Rho's components have almost identical magnitudes and are separated by a comfortable 3.5 seconds of arc; but with the exception of two other eighth magnitude stars (one of which is a double itself), the surrounding area is almost completely devoid of stars. This paucity is due to another of Barnard's nebulae — a large complex of both bright and dark clouds, which obscures the

TABLE OF OBJECTS IN OPHIUCHUS

Globular Clusters

NGC	Messier Object	Mag.	Size	R.A.	Dec.
6171	M-107	9	2.2'	16^h31^m	-12°59'
6218	M-12	6.5	9.3'	16^h46^m	-01°54'
6254	M-10	6.5	8.2'	16^h56^m	-04°04'
6273	M-19	7	4.3'	17^h01^m	-26°13'
6284		10	1.5'	17^h03^m	-24°43'
6287		10	1.7'	17^h03^m	-22°40'
6293		8	1.9'	17^h08^m	-26°32'
6304		10	1.6'	17^h12^m	-29°26'
6316		10	1.?'	17^h15^m	-28°07'
6333	M-9	7.5	2.4'	17^h17^m	-18°29'
6356		9	1.7'	17^h22^m	-17°47'
6402	M-14	8	3.0'	17^h36^m	-03°14'

Double Stars

Star	Mag.	Sep.	Colors	R.A.	Dec.
ρ	5.2 - 5.9	3.5"	Yellow, blue	16^h24^m	-23°23'
36	5.3 - 5.3	4.8"	Yellow, red	17^h13^m	-26°31'
o	5.4 - 6.9	10.8"	Yellow, blue	17^h16^m	-24°15'
70	4.2 - 6.0	1.9"	Yellow, red	18^h04^m	+02°33'

Planetary Nebulae

NGC	Mag.	Size	R.A.	Dec.
6572	10	7"	18^h11^m	+06°50'

Epoch 1970

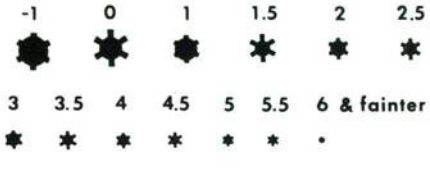
light from more distant stars. Photographs of the region dramatically reveal the "awesome activity" suggested by Pickering, although once again very little can be detected visually. The observer cannot help but be aware of the absence of background stars, however, and of a persistent soft glow to the entire field of view. It is as if there is always a slight haze over this area, or constant interference from a too bright moon.

Two unique objects in Ophiuchus that are often overlooked are NGC-6572, a planetary nebula, and R Ophiuchi, a long period variable star. NGC-6572 is located in the northeast corner of the constellation, three degrees south of 72 Ophiuchi. Only seven seconds of arc in diameter, it is very starlike when viewed at low power and is therefore easy to miss. Fortunately it is also extremely bright for a planetary, and has a striking blue color that is sure to attract your attention. Once found, it stands out clearly in contrast with the surrounding stars.

Color also betrays the presence of R, conveniently situated less than one degree west of Eta Ophiuchi. Like many other long period variables, it has a definite red-orange color. R has a period of 302 days and varies in magnitude between 6.2 and 14.4. It was predicted to reach a peak of 7.6 in early May 1974 and was, indeed, very conspicuous at that time. It should now be fading again, with the next minimum due near the end of September. It is difficult to know how prominent it will be during August, but its convenient location makes it inviting to check and see.

Overshadowed by brilliant neighbors on all sides, Ophiuchus has been a much neglected constellation. There are so many celestial showpieces to choose from during the summer months that little thought is usually given to this relatively dull region in the southern sky. As we have seen in previous months, however, there is often much more to a constellation than what first meets the eye. Such is certainly the case with Ophiuchus. Wait for a clear, dark, moonless night — and then you will see where much of the summer action is! "Something is there... there is no doubt of it."

Stellar Magnitudes

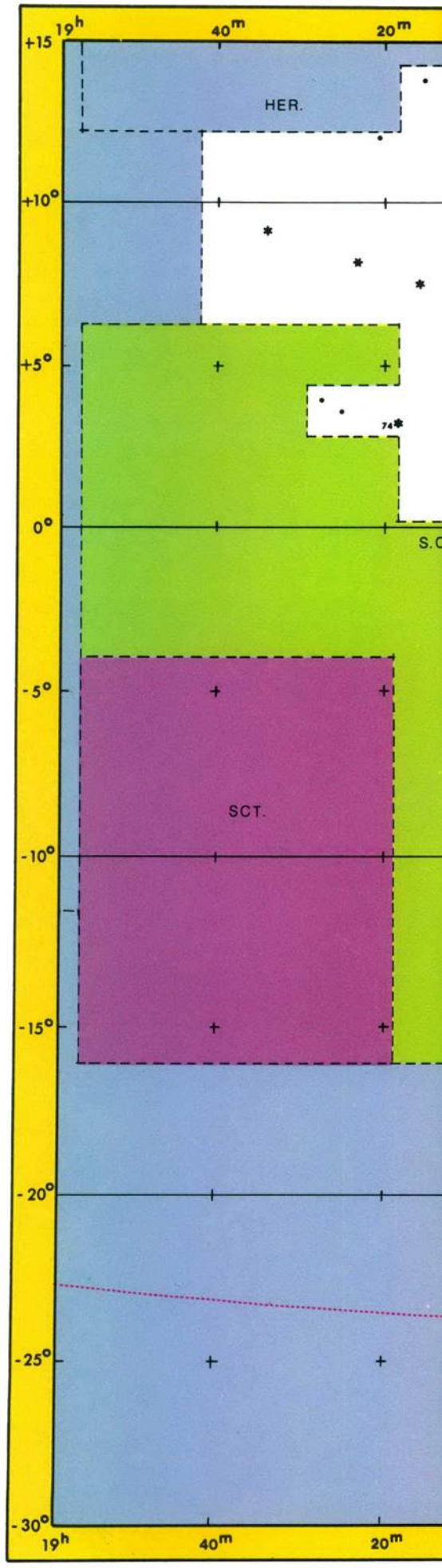


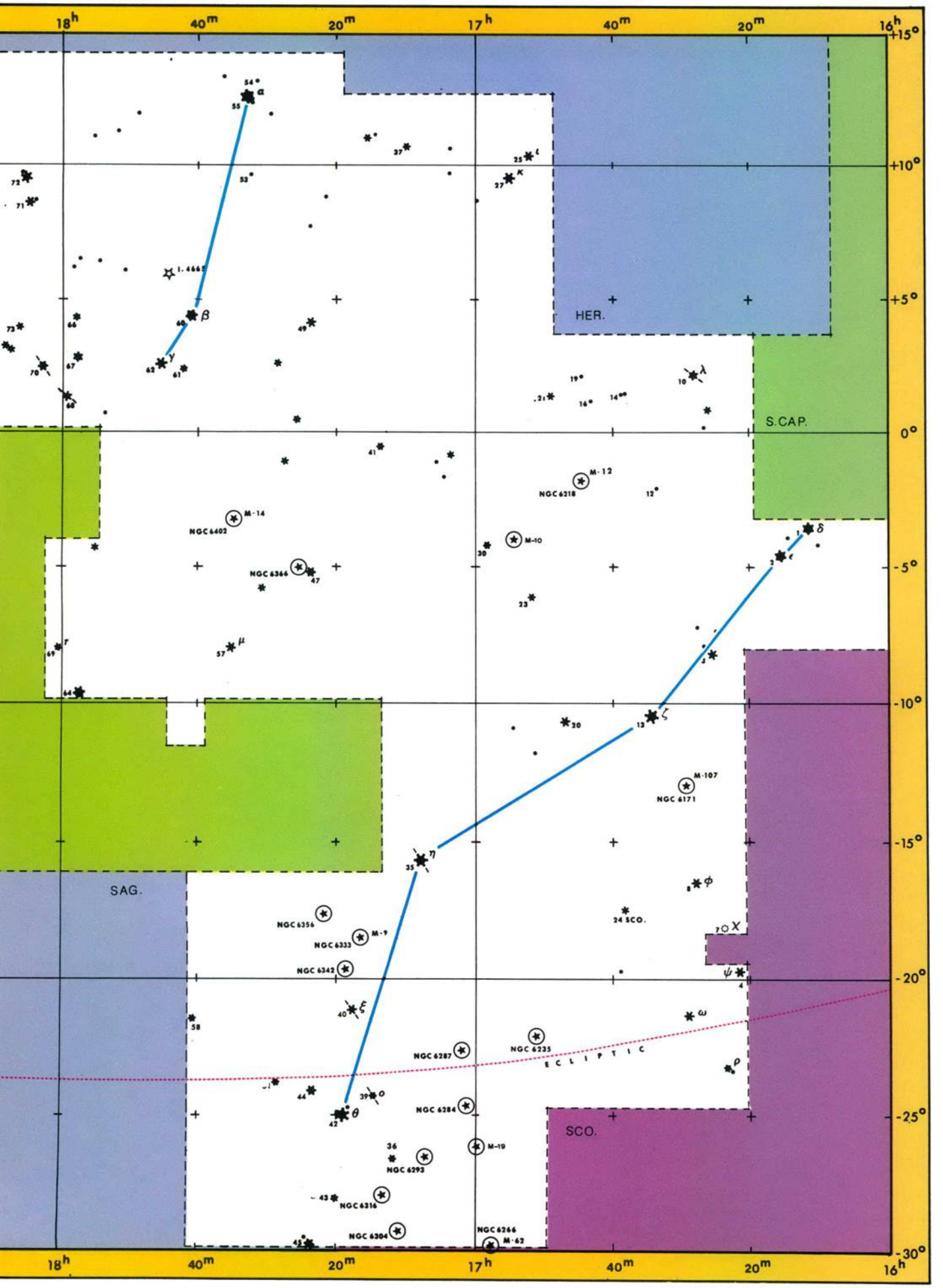
Double Stars Diffuse Nebula

Planetary Nebula Variable Stars

Galaxies Open Star Clusters

Globular Clusters





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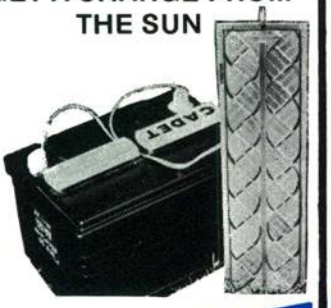

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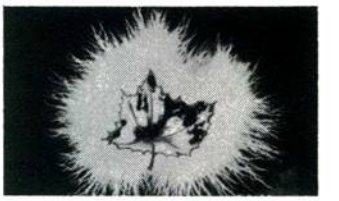

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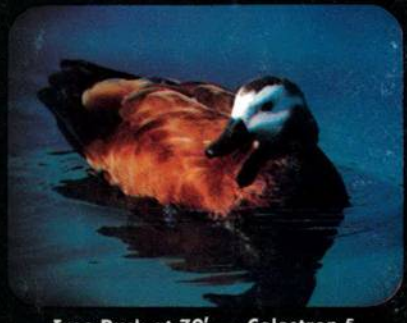

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